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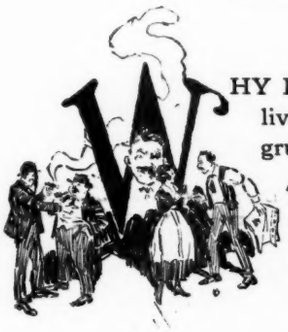
Two-Faced Tom

BY RUFUS T. STROHM



WHY IS IT that so many men who live respected business lives grow grim and grouchy now and then and act so gruffly with their wives?

Take Thomas Tyler as a case: He runs the engines and the pumps at Sanderson Miller's place; he plugs the leaks and fixes thumps. His ready wit and jollity have won his fellows' hearts to him; his cup of gladness seems to be forever spilling at the brim. But when the evening whistle blows to end the labor and the grind, and Thomas slowly homeward goes, he leaves his cheerfulness behind.

On entering his cottage door, with wrinkled brow and sullen jaw, he's just about as peeved and sore as Bruin with a festered paw. He dims the gas-light's cheery ray with gloom so thick it can be felt, till he begins to stow away the evening meal beneath his belt. And then, perhaps, he deigns to speak in glum and pessimistic tones, bewailing that his wage per week amounts to only thirty bones.

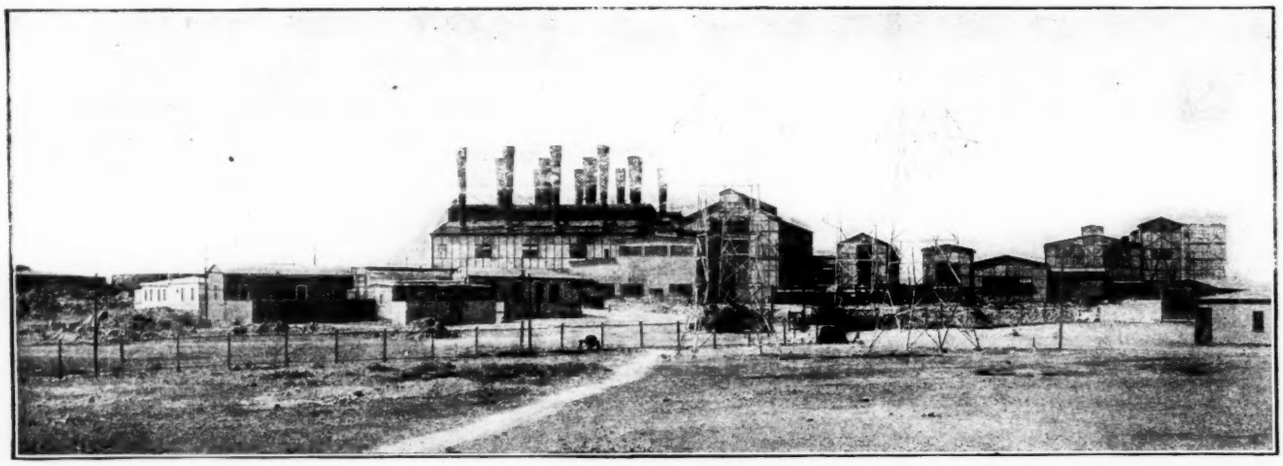
He swears he's worth three times as much to any company in town and vows it surely beats the Dutch the way his bosses grind him down. His fellow-workmen have no brains; their skulls are stuffed with cotton wool; his super only holds the reins because of politics and pull.

And thus he grumbles and he rants of circumstances, men and things, till supper's over, and, perchance, the silver-plated door-bell rings. Then Thomas ends his verbal war; his voice grows suave, his smile grows bland; he leaps to meet the visitor with greetings warm and gladsome hand. But when the caller says goodnight and takes departure from the room, then Tom forgets to be polite and dons again his cloak of gloom.

His patient wife essays to play, to read to him, perhaps to sing, in hopes that she may drive away the blues that color everything; while Thomas sits, morose and gruff, as though in contemplation deep; but this is quackery and bluff, for soon he yawns and falls asleep.

His friends are glad to see his face and shake his hand where'er he goes; they like to have him round the place. But not his wife!—she knows, she knows!

The above was inspired by a letter received from a lady in Toronto, evidently the wife of a "Two-faced Tom," who had read the foreword on "The Chronic Grouch" in the Jan. 13 issue. She is probably only one of many.—EDITOR.



Chile Exploration Company's Tocopilla Power Plant

Plant of 50,000 Kw. Capacity, 4,000 Miles From Fuel Source, Located Where It Never Rains and Where Earthquakes Are Prevalent

CHILE, located on the west coast of South America, is a narrow strip of country extending a total length of approximately 2,700 miles and has a width varying from 248 to less than 70 miles. For about 1,000 miles of the northern portion the coast is nearly a straight line, offering practically no harbor facilities. This coast line is bordered by a diversified tableland rising sharply out of the sea to a height of from 2,000 to 9,000 ft. Around this locality it seldom rains and the rivers are of little consequence. In a section of this country which is practically a desert, about 1,400 miles south of the equator, without any roads, railways or other arteries of transportation, 4,000 miles away from a fuel supply, where there is no fresh water other than that distilled from sea water, and where earthquakes are prevalent, the problem of building a power plant of 50,000 kw. capacity, to operate a copper mine and refinery ninety miles inland from the coast, has been successfully solved by the Chile Exploration Co. and the contractors for the original plant.

At the regular monthly meeting of the New York Section of the American Institute of Mining Engineers, New York, Jan. 7, 1920, Percy H. Thomas addressed the meeting on "Steam and Hydro-Electric Power Problems" in Chile. This article is based on that address, and describes the power equipment of the Chile Exploration Co.'s plant at Tocopilla, Chile.—Editor.*

The design work was started in 1913, and the first machine was put in operation in 1915. After considering the various factors to be contended with, it was decided to use steam as the primary source of power and locate the power plant on the coast at the small town of Tocopilla, about 100 miles north of the Tropic of Capricorn. Hydro-electric power was considered, but was abandoned for the time on account of the problems involved in development and the uncertainty of the waterflow. Building an oil-engine plant at the mine was also considered, but this was abandoned because of the great number of machines that would be required in a plant to supply 50,000 kw., the high altitude at which the engines would be operating (barometer at the mine only 70 per cent of that at sea level) and the difficulty of transporting the oil. When the decision of a steam plant was made, the choice of oil or coal for fuel was carefully gone into, and it was decided to use oil. One of the chief factors that influenced this decision was the ease with which the oil could be unloaded from the boats. The boats are anchored off shore and a pipe line laid out to them on floats, and the oil pumped to the storage tank of the plant. On account of there being no harbor to offer protection from the ocean waves, it would be very difficult to unload coal from boats at a dock. Furthermore, if coal were used it would have to be brought from the United States, England or Australia, since Chilean coal is mined only in small quantities.

Oil for fuel is stored in three 55,000 gal. tanks built of steel. Concrete was considered for the construction of the tanks, but was found to be too expensive and not as satisfactory as steel, which is less liable to rupture from earthquake disturbances.

At Tocopilla, where the power plant is located, the country is practically all solid rock, rising sharply out of the sea, and it was in this rock that a foundation for the plant was blasted. The power-plant building has an extra-heavy steel framework, rigidly braced to withstand the effects of earthquakes, with reinforced-concrete slabs bolted to the steel.

The boiler plant contains sixteen 600-hp. and two 1,350-hp. marine-type B. & W. boilers arranged along three aisles. Four of the 600-hp. boilers are on each side of two of the aisles and the two 1,350-hp. boilers on one side of the third aisle. Each boiler is equipped with superheaters operating at a pressure of 177 lb. and superheating the steam to a total temperature of 600 deg. F. Steel-tube economizers are built in as part of the boiler, which heats the feed water from 130 to 180 deg. F. to the temperature at which it enters the boilers. These economizers have given satisfactory operation, no serious trouble having been experienced from cor-

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rosion. This is due largely to the purity of the feed water and to its temperature when passing through the tubes. The temperature is of a value that prevents the tubes from sweating and causing external corrosion. Provisions are being made to increase the temperature of the feed water entering the economizers, as it is felt that the temperature, with the present arrangement, at times gets down near the point where sweating of the tubes might be caused.

The oil-storage tanks are located higher than the fuel pumps, so that the oil flows to the pumps by gravity, where it is pumped to the burners at a pressure of 165 lb. per sq.in., and is mechanically atomized, therefore no steam is required in burning it, which makes this type of burner very economical for this locality, where every pound of steam blown to the atmosphere means a pound of fresh water that must be distilled from sea water by the burning of expensive fuel. When the oil burners were first installed, some difficulty was experienced with the flame destroying the furnace walls, but by a proper arrangement of the burners in the furnace this trouble has been entirely overcome. There is no fresh water at Tocopilla other than that distilled from sea water, consequently all feed water for the boilers must be distilled. Evaporators are used similar in type to those used on ships. Salt water is pumped into a large closed tank, which contains coils of pipe connected to the boilers. Steam at 177 lb. and 600 deg. F. total temperature is supplied to the coils, which in turn evaporate the sea water in the tank, the evaporation passing off to the feed-water heater, where it is condensed by coming in contact with the condensate from the condensers on the main turbines. This type of evaporater is very economical, since, if it is properly insulated, practically no heat is lost, all the heat required to evaporate the water being passed back into the boilers in the feed water. An important factor in the use of an evaporator to obtain the feed water is that no scale is formed in the boilers, therefore the necessity of cleaning them is practically eliminated. Where impure feed water is used, there is always danger of burning a tube where a patch of scale has formed. With distilled water, on the contrary, there is no formation of scale, consequently the boilers can be forced without danger of burning the tubes.

The gases from the furnace make three passes through the boiler and three in the economizer. The boiler and economizer, being in series, the gases therefore make a total of six passes from the furnace to the stack. Natural, forced and induced draft are used. The height of the stacks had to be limited to about eighty feet to make them earthquake-proof as far as possible, and they are built of steel. Their general arrangement is clearly indicated in the headpiece. Each boiler has its own stack, and induced draft is obtained by blowing cold air up the stack, thus creating an ejector effect that draws up the hot gases. Although this scheme obviates the troubles encountered when the hot gases are taken through the fan, it has not been entirely satisfactory, and a change to a standard induced fan equipment is under advisement at this time. With the present draft 5,000-volt turbo-alternators operatated at from 150 to 175 per cent of their normal rating. Part of the auxiliaries in the boiler room are steam-driven and part are electrically driven; the steam-driven units exhaust into the early stages of the turbines.

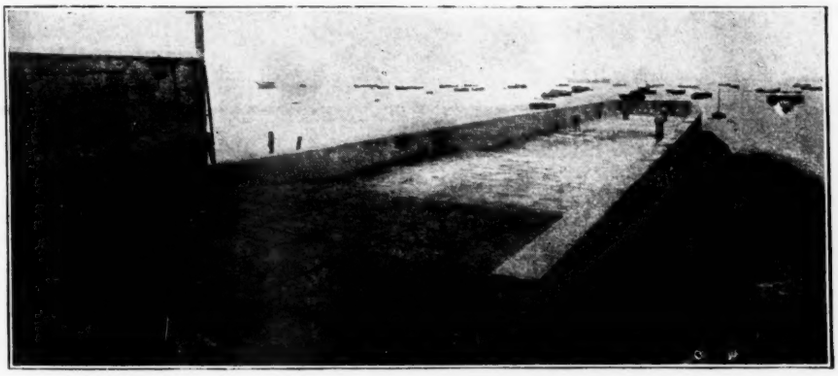


FIG. 2. BREAKWATER PREVENTS SEAWEED FROM GETTING INTO INTAKE TUNNEL

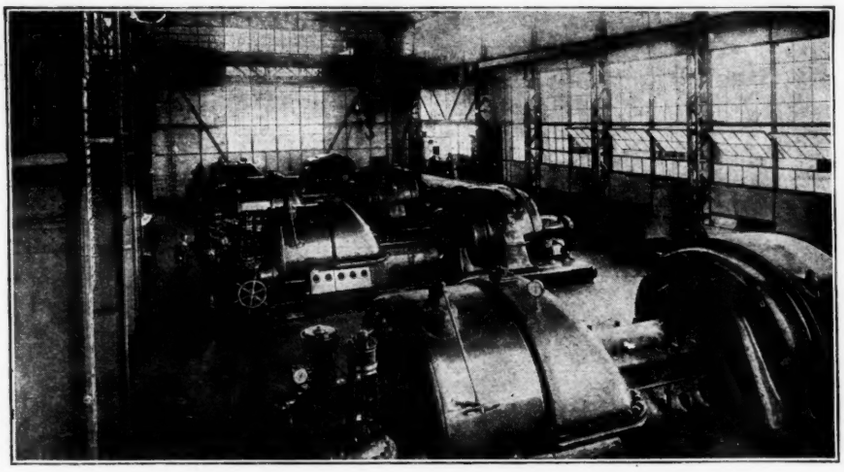


FIG. 1. INTERIOR VIEW OF TURBINE ROOM

The power plant contains five 10,000-kva., 50-cycle, three-phase, 5,000-volt turbo-alternators operating at 1,500 r.p.m., four of which are shown in Fig. 1. Excitation for the alternators is obtained from 220-volt direct-connected exciters. The turbines have twelve stages, take steam from the boiler at 177 lb. pressure and 600 deg. F. total temperature and exhaust into three-pass condensers having 20,000 sq.ft. of cooling surface. With cooling water at from 57 to 67 deg. F. a vacuum of from 28.5 to 29 in. is maintained. The circulating pump, air pump and hotwell pump for each unit are all driven by the same turbine at 1,500 r.p.m., the turbine exhausting into the low-pressure stages of the main turbine.

One of the most serious problems to contend with in the operation of the plant was the large quantities of seaweed washed into the circulating-water intake tunnels. There being no harbor or breakwater, it is not

hard to imagine the large quantities of this material that would be broken loose by the waves washed in on shore and drawn into the intake tunnel by the flow of the water. In the early period of the plant's operation, before suitable means had been devised for preventing this material from getting into the intake tunnel, 600 wheelbarrow loads of seaweed were taken out of the intake racks in one night. This situation has been successfully

FIG. 3. MUMMIFIED MULE GUIDE POST

met by building a short breakwater, Fig. 2, out from shore to deflect the seaweed away from the intake tunnel and by the use of double racks and revolving screens in the intake.

The switching and bus arrangement for the generators is installed according to standard practice; namely; a standard-type double bus with remotely controlled oil switches to connect the generators to either busbar. Power for operating the oil switches is supplied from a storage battery. From the generator busses the 5,000-volt current passes through another set of oil switches to 10,000-kva., oil-insulated, water-cooled, three-phase star-to-star connected transformers, where it is stepped up to 110,000 volts and transmitted ninety miles across the desert to the copper mines and refinery of the Chile Copper Co. at Chiquicamata. There are five of these transformers, one for each generator, which may all be grouped in parallel, or any one of the transformers can be connected to any one of the generators. Each transformer is equipped with an oil conservator—a small auxiliary tank, having about 8 per cent of the capacity of the transformer tank, mounted above the main tank and connected to it through a single-pipe connection. Under normal operating conditions the conservator is maintained about half full of oil; thus at all times the main tank is kept full of oil, and air is prevented from coming in contact with the warm oil and causing sludging.

Instead of the water-cooling coils being located in the top of the transformer tank, they are placed in a separate tank of cooling water and connected with the top and bottom of the transformer tank through a pump. The oil is pumped from the top of the tank through the coil in the cooling tank containing sea water, and back into the bottom of the transformer tank. This eliminates the problem of keeping the cooling coils clean when sea water is pumped through them, and also the danger of this water getting into the oil. To prevent electrolytic action between the iron cooling coils and the sea water, a large piece of zinc is immersed in the water and connected to the cooling pipes above the water line, thus forming a battery with the zinc in the water electro-positive to the iron cooling pipe. This scheme has proved very successful in preserving the cooling coils, and only requires renewing of the zinc electrodes at such intervals as they may become decomposed.

For the first ten miles the transmission line is in duplicate, but for the remaining eighty miles a single line is used. Since this line was placed in operation, in 1915, the service has been interrupted but once due to line trouble. For approximately eight or ten miles from the coast a salt mist from the sea is carried inland and falls on the insulators, where it evaporates and leaves a salt deposit, which eventually would cause flashovers. This condition was taken care of by building the line in duplicate, and while one line is in service the insulators on the other are washed. The insulators are washed about every two weeks, which has eliminated all trouble on this section of the system. On the remaining eighty miles the conditions are very favorable for continuous operation, the insulators are of good quality, the climate is very dry, and since there are no large birds, or thunder storms, or individuals walking around with rifles, there is practically nothing to disturb the operation of the line. Men are kept going over the line all the time, testing insulators, and in this way defective insulators are detected and removed before they cause trouble. The difference in the climate inland from that near the ocean

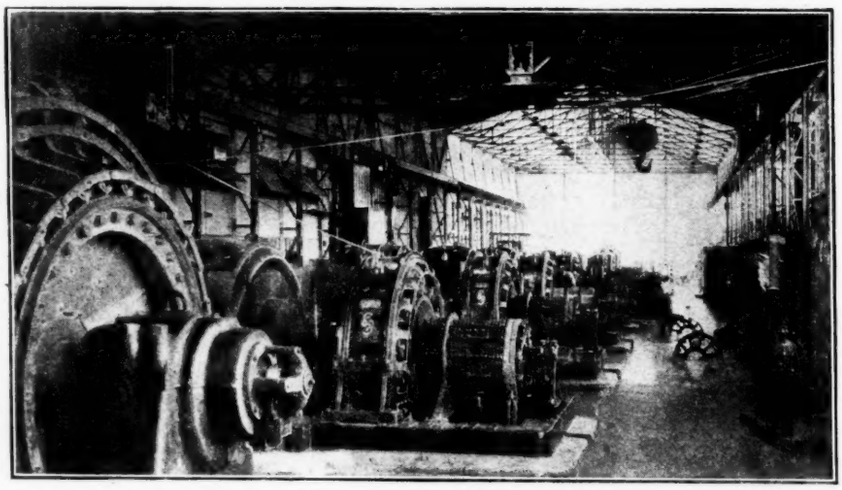


FIG. 4. INTERIOR VIEW OF SUBSTATION

is shown by the fact that insulators that are of good quality when used inland will deteriorate rapidly if taken down to the coast. When these insulators are taken inland again, they will regain their original high insulating qualities, showing that the deterioration is due to moisture. The climate is so dry inland that dead animals do not decay but dry up, as indicated in Fig. 3, which shows a mummified mule set up in the desert for a guide post.

At the mine substation the 100,000-volt current is stepped down through three-phase transformers to 5,000 volts for distribution about the mine, smelter and refinery. In the substation, the interior of which is shown in Fig. 4, there are seven motor-generator sets, each consisting of a 5,000-volt, 4,000-hp. motor directly connected

to two 1,325-kw., 220-volt direct-current generators. Each generator delivers a normal full-load current of 5,300 amperes, or a total of 10,600 amperes per set. Four of the motors driving these sets are of the induction type and three of the synchronous type. There are also two 1,000-kw. 5,000-volt synchronous-motor 220-volt direct-current generator sets and four 3,500-kw. booster-type rotary converters. The latter are capable of delivering a normal full-load current of 12,000 amperes. When the converters were installed, it was not known just what the voltage requirements would be in the tankhouse, so in order to meet any conditions that might arise they were designed for a direct-current voltage range of 120 to 290 volts. The lower ranges of voltage are obtained by two-thirds voltage taps on the transformer secondaries. Direct-current voltages from 120 to 208 are obtained when the slip rings of the converter are connected to the two-thirds taps on the transformers, and 202 to 290 volts is obtained on the commutator with full secondary volts on the slip rings. Each group of two converters are supplied with alternating current through the same three-phase transformers, which steps the 100,000-volt current down to 180 volts on the secondary with a tap brought out to give two-thirds of 180, or 120 volts. The transformers have two secondaries, one for each rotary, and switches are arranged so that both converters may be operated from the transformers at the same time or either one may be operated separately.

An interesting feature of the power equipment at the mine are the electrically operated shovels. These were among the first electrically operated shovels in use, and many of the features of design are original. These shovels, of which there are four 100-ton and one 200-ton, do all that could be expected of steam shovels and do it as satisfactorily. There are three motors on each shovel—a hoist motor, a swing motor and a thrust motor. The motors are of the wound-rotor alternating-current type and are supplied with three-phase power from transformers located on the shovels, which step the 5,000-volt current down to 500 volts. The control is arranged so that the operator manipulates it as he would that of a steam shovel. To prevent the operator from abusing the electric equipment and the shovel from overloads, current-limiting relays are connected in circuit, which, when the current to the shovel motors exceeds a predetermined value, operate and cut a resistance in circuit that limits the power to a safe value.

Most of the equipment for the first 40,000-kw. installation in this project was manufactured in Europe. The last addition made to the plant, which includes two 1,350-hp. boilers, a 10,000-kva. turbo-alternator, one 10,000-, one 7,000- and two 3,500-kva. transformers and the four 3,500-kw. rotary converters are American-made equipment as are also all the electrically operated shovels.

Another problem of considerable moment at the mine was that of a water supply, both for industrial purposes and for drinking. Since about 2,500,000 gal. per day is required for industrial purposes, besides drinking water for 10,000 inhabitants, in a land where it seldom rains, the supply must be not only abundant, but also reliable. The industrial-water supply was obtained by running a 12-in. pipe line back into the mountains forty miles, and the drinking water is brought through a pipe line sixty miles long.

Plans are under way to make a number of refinements in this installation to meet the conditions found down in that locality. When these are made and test data are available, *Power* expects to be able to present to its readers a story on the operation of this installation.

Air-Compressor Lubrication

By W. F. OSBORNE

This article discusses the peculiar problems that arise in the lubrication of the cylinder of an air compressor. The common practice of requireing a high flash-test oil for such work is shown to be wrong. The physical characteristics of air-compressor oil as worked out by members of the Compressed Air Society are given in tables.

THE air cylinder of a compressor is the part given the greatest attention with respect to lubrication. The steam cylinder and bearings are lubricated just like those of any steam engine, and the recommendations made in previous articles on the steam engine apply here also. Vertical single-stage air compressors that are completely inclosed and depend upon a bath of oil in the crank case for the lubrication of all bearings and cylinders, of course, require an oil that is suitable also for the cylinder lubrication.

An air cylinder is very simple to lubricate as far as the reduction of friction between the piston, piston rings and cylinder walls is concerned. The oil is fed to the cylinder through vacuum cups or by mechanical lubricators and is usually introduced directly into the top side of the cylinder or into the air-intake pipe just above the admission valves. It is spread over the cylinder walls by the sweep of the piston, preventing wear and loss of power. The oil film also improves the seal between the piston and cylinder, thereby increasing the efficiency of the compressor. It is easy to select lubricants that will do all of these things efficiently and economically for a short time, but when the compressor has run for a few days, a number of things begin to happen if the oil does not have certain qualities necessary to prevent them.

Air drawn into a cylinder and compressed, rises in temperature. Table I shows the temperatures of the discharged air at various pressures. Actual temperatures are somewhat lower than these owing to the cooling effect of the water jackets or cooling ribs around the cylinders. In any event, however, the temperature is high enough to cause some evaporation of the oil film. Many engineers have believed for a long time that if the flash point of the lubricating oil were not higher than the temperature of the air, a fire or explosion would take place, and on this account it has been customary in some localities to insist upon the oil having the highest flash point obtainable.

Now let us see what this means. In the first place a mixture of oil vapor and air will not ignite of itself under about 1,000 to 1,100 deg. F. A flame, incandescent point of carbon, electric spark or red-hot

metal is necessary to cause the flash. Unless these exist in the cylinder, on the discharge valves or in the discharge pipe, there can be no flash. Further, the increased pressure in the cylinder raises the flash point of the oil, or in other words, it reduces the amount of vaporization. Consequently, there can be no danger of fire or explosion even when comparatively low-flash oils are used, unless something else is present to fire the vapor.

Oil Remaining in Cylinder Is Decomposed

When an oil film has once been formed on the cylinder walls, the only way for the oil to get out of the cylinder is for it to evaporate and be carried out with the air. As an ordinary two-stage compressor, compressing air up to 100 lb. pressure, has a normal discharge temperature of less than 245 deg. F., this oil film is undoubtedly going to last a long time before it is completely evaporated. This is borne out by everyday practice, which shows that very small quantities of oil are required to give proper lubrication. Naturally, when the oil is exposed to this heat for a considerable length of time, it begins to break down or decompose, forming carbon. This is particularly true when oil is fed faster than it can be evaporated, causing accumulations at the end of the cylinder and on the discharge valves.

If this partly decomposed oil collects on the discharge valves which are subjected to the highest temperatures, further decomposition or carbonization takes place and deposits of carbon form. Frequently, these deposits get large enough to cause the valves to stick. When this happens, the hot discharged air leaks back into the cylinder, where it is again compressed, still further raising the temperature. The higher temperature causes greater carbonization and more trouble with the valves. This may finally reach a stage where the carbon deposits are so large and the air so hot that small particles of the carbon actually become incandescent. Then there is a possibility that a fire or explosion of ignited oil vapor will occur. Even if a fire does not develop, the carbon deposits on the discharge valves greatly decrease the output and the efficiency of the compressor.

As we have just explained, the decomposition of the oil and the resulting carbon deposits are caused by the oil remaining in contact with the hot air too long. If it had been completely evaporated soon enough to prevent decomposition and carried out of the cylinder with the air, there would have been no deposits and no trouble.

Less Danger from Low Flash-Test Oil

Now let us see whether we shall still insist upon a high flash-test oil. The flash test shows that it requires a certain temperature to evaporate the oil. This means that a low flash-test oil will evaporate more quickly at a lower temperature and that the high flash-test oil will remain in the cylinder longer. This gives it a greater chance to decompose. If we use a low flash-test oil that will evaporate quickly without decomposition, it will be carried out with the air before it has a chance to decompose and form carbon deposits. With the carbon deposits eliminated, there can be nothing to ignite the oil vapor and no fires or explosions can take place. At the same time most of the troubles due to leaky discharge valves have been removed.

Theoretically, the low flash-test oils might perhaps require a slightly greater amount to maintain the film on the cylinder walls, owing to their greater evaporation, but in actual practice it is not possible to regulate the feed fine enough to show any difference in consumption.

Investigation of explosions occurring in the discharge lines seems to point to the fact that they are caused by oil pools forming in depressions in the pipes and becoming heated by the discharge air. The long exposure to heat causes the oil to decompose, forming carbon deposits. These deposits may build up to such an extent that they obstruct the air passage, and the friction of the air through the greatly reduced space causes them to become red hot. The pipe in turn is heated, its strength reduced and the pressure of the air within the pipe causes it to give way. Excessive amounts of oil fed to the air cylinder are responsible for most of this trouble, and it should always be reduced to a safe minimum. All receivers and discharge lines should be provided with suitable drains to draw off any oil collections.

Tests to Determine Causes of Carbon Deposits

In order to check up definitely the causes of carbon deposits in air cylinders, a prominent builder of air compressors arranged for a series of tests to find out the effect oils of different characteristics have when compared under identical operating conditions. The compressor selected for this test was a vertical single-stage machine delivering air at 110 lb. per sq.in. pressure with a temperature of about 425-450 deg. F. These temperatures are considerably higher than those ordinarily met with and for which previously it had been considered necessary to use a high flash-test oil of heavy body. Cylinder and bearings were lubricated by the splash method from the crank case. In each instance the test was continued for one hundred hours and the valves examined at the end of this time.

The first oil tested was a heavy-bodied straight-run oil having a flash test about 70 deg. F. lower than the temperature of the discharged air. On examination at the end of the run the valves were found to be exceptionally clean, there being no carbon deposits.

The second oil tried out was heavy-bodied but slightly thinner than the first, by blending a light-viscosity oil with a heavy filtered, dark-green cylinder oil to raise its viscosity and to obtain a high flash test. This oil was similar in characteristics to the usual high flash-test oil recommended for air cylinders. At the end of the run the discharge valves were so badly carbonized that if the test had been continued much longer they would have begun to leak.

The third test was made with medium-bodied straight-run oil having a lower flash than either of the two samples previously tested and at the end of the run showed only a very slight carbon formation.

In all three tests the cylinder walls showed perfect lubrication. An analysis of these three runs shows that in the first test the oil evidently evaporated cleanly without decomposition and was carried out of the cylinder with the air. When the high-flash blended oil was used, the light-bodied portion of it apparently evaporated all right, but left the heavy portion on the discharge valves, where it could not completely evaporate fast enough because of its high flash, so it gradually carbonized.

The third oil probably evaporated cleanly, but because it was too thin in body, excessive amounts worked past the piston rings faster than it could be carried out of the cylinder, with the result that some of it stayed in the cylinder long enough to become partly decomposed. This is good evidence that the amount of oil fed to the cylinder should always be reduced to a minimum.

From these tests the conclusion might be reached that the lowest flash-test oils are the best for air-cylinder lubrication. It should be remembered, however, that it is quite possible for a heavy-bodied high-flash oil to be blended with an extremely low flash oil, thus giving a low flash test to the finished product, but when the light part of the oil has evaporated, the

TABLE I. CYLINDER TEMPERATURES AT THE END OF THE PISTON STROKE

Final Pressure, Lb. per Sq.In. Gage	Final Temperature, Deg. F. Single-Stage	Two-Stage
10	145	...
20	207	...
30	255	...
40	302	...
50	339	188
60	375	203
70	405	214
80	432	224
90	459	234
100	485	243
110	507	250
120	529	257
130	550	265
140	570	272
150	589	279
200	672	309
250	749	331

heavy portion will remain and form carbon. Consequently, the statement that, in general, the low flash-point oils are more suitable for air cylinders applies only to properly refined straight-run oils.

Of the different viscosity oils which can be made from the same crude the thinnest will have the lowest flash point. Following out the previous statements, we might now reach the conclusion that the thinnest oils are best for air-compressor cylinder lubrication. This is quite correct, provided they are heavy enough in body to keep the piston and piston rings from wearing out through friction. They must also provide a sufficient piston seal to prevent excessive leakage of air and, in the case of splash-lubricated cylinders, to prevent excessive amounts working into the

TABLE II. PHYSICAL TESTS OF PARAFFIN-BASE OILS

	Minimum	Average	Maximum
Gravity, Baumé	28–32 deg.	25–30 deg.	25–27 deg.
Flash point, open cup	375–400 deg. F.	400–425 deg. F.	425–500 deg. F.
Fire	425–450 deg. F.	450–475 deg. F.	475–575 deg. F.
Viscosity (Saybolt) at 100 deg. F	120–180 sec.	230–315 sec.	up to 1500 sec.
Color	Yellowish	Reddish	Dark red to green
Congealing point (pour test)	20–25 deg. F.	30 deg. F.	35–45 deg. F.

cylinder. This was the trouble in the third test; the oil was so thin that it leaked past the piston rings faster than it could be carried away with the air.

Another reason for using light-bodied oils is the fact that there is less possibility of their holding dust and foreign matter carried into the cylinders by the air. Heavy oils, being more adhesive, naturally hold this dirt more closely and eventually form deposits composed of a little oil, some carbon and a lot of foreign matter.

An oil suitable for air compressors should always be highly filtered because such an oil will have a minimum tendency to form carbon deposits, as shown by the carbon-residue test. The light-bodied oils by this test also show less carbon residue than the heavier-bodied ones, when made from the same crudes. The carbon-residue test is therefore of much assistance in comparing oils for air-cylinder lubrication.

Needless to say, oils compounded with vegetable or animal oils are quite unsuitable for air cylinders because of their great tendency to decompose under heat with the formation of carbon deposits.

The pour test of the oil need receive attention only when the lubricators are exposed to temperatures below 35 deg. F. For such installations the oil should

TABLE III. PHYSICAL TESTS OF ASPHALTIC BASE OILS

	Minimum	Average	Maximum
Gravity, Baumé	20-22 deg.	19.8-21 deg.	19.5-20.5 deg.
Flash point, open cup	305-325 deg. F.	315-335 deg. F.	330-375 deg. F.
Fire	360-380 deg. F.	370-400 deg. F.	385-400 deg. F.
Viscosity (Saybolt) at 100 deg. F	175-225 sec.	275-325 sec.	475-750 sec.
Color	Pale yellow	Pale yellow	Pale yellow
Congealing point (pour test)	0 deg. F.	0 deg. F.	0 deg. F.

have a pour test low enough to insure a satisfactory feed through the lubricators or free flowing of the oil when used in a splash system.

A final specification for good air-compressor oils might be written somewhat as follows:

Use only a straight-run, highly filtered, pure mineral oil, of the lowest natural flash test consistent with the viscosity necessary to lubricate the cylinders and provide a proper piston seal.

The correct viscosities, as worked out by the members of The Compressed Air Society, all of whom are builders of air compressors, are given in Tables II and III, showing the proper specifications for both paraffin and asphaltic oils of various viscosities.

Hydro-Electric Plant Hints

By L. W. Wyss

The hydro-electric plant operator keeps in touch with water conditions by keeping a record of the head- and tail-water elevations as well as the amount of water used and wasted.

The head water is obtained from a pressure gage, float gage or water column; the tail water is obtained with a float gage or measuring stick.

The water used can be obtained from kilowatt-hour output discharge curves and the water wasted is obtained from curves which show the rate of flow for different gate openings and head-water elevations. The most common unit for measuring water is the cubic foot per second.

Not many years ago 80 per cent efficiency was considered excellent, but now there are numerous turbines with efficiencies of 89 to 92 per cent, and the maximum obtained so far is 93.7 per cent.

At some plants, during low-water periods, trouble is experienced with turbines losing their vacuum in the draft tubes. This may cut down their efficiency and output over half in the case of low-head plants, beside causing poor speed regulation. When turbines lose their vacuum the governors, of course, open the gates, attempting to keep the speed normal. In order to carry the same load without vacuum in the draft tubes more water is used. This water may raise the tail water and the vacuum may soon be regained in some cases. However, it may be advisable to obtain more load, start idle machines or waste water at the spillway to raise the tail water, thus regaining the vacuum.

Automatic Control for Motors Driving Pumps and Compressors

By B. W. JONES
Engineer, Industrial Controller Department, General Electric Company

The characteristics of the motors used to drive pumps, compressors and fans are discussed, then types of controllers used to start and stop these motors automatically are considered.

DIRECT-CURRENT and alternating-current motors are both employed for driving pumps and compressors. Of the direct-current motors the constant-speed and the adjustable-speed shunt types are most generally used; and of the alternating-current motors the squirrel-cage and slip-ring induction types and the synchronous type are most commonly employed. Using these five types of motors, the table shows that there result eighteen variations with some duplicates in the automatic control. Therefore it becomes essential for the purchaser to decide which of these conditions he will have, and then pass this information on to the manufacturer of the controller. It is the object of this article to show wherein each of these eighteen conditions differ and also to give some details of the operation of the several types of automatic control.

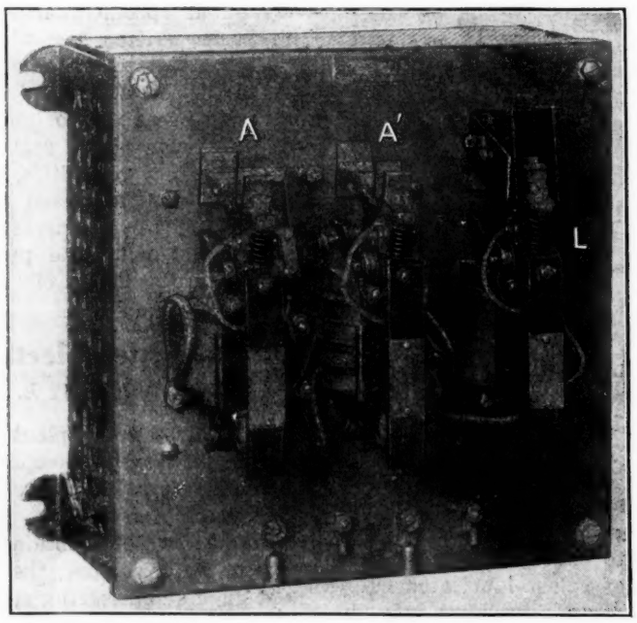


FIG. 1. CONTROLLER USED FOR STARTING CONSTANT-SPEED DIRECT-CURRENT MOTORS

Reciprocating pumps when loaded require constant torque, independent of the speed, which means that if the motor is started up against full accumulator pressure, more than full-load torque will be required to accelerate the motor. It is, therefore, desirable to have some form of unloader that will remove the pump load during the accelerating period.

Centrifugal pumps, when loaded against a constant head, require a driving torque that varies approximately as the square of the speed. This application does not require an unloader during the starting period so much as the reciprocating pumps, but it is very desirable as will be indicated in the table.

The characteristics of the squirrel-cage and wound-rotor induction motors have been well brought out in Mr. Fraser Jeffrey's article in the Aug. 26, 1919, issue of *Power*. The synchronous motor has a starting characteristic very similar to that of the squirrel-cage induction motor, but the necessary control is somewhat more elaborate and requires a little more care during the starting period.

The direct-current constant-speed shunt motor has a torque directly proportional to the armature current. The adjustable-speed shunt motor has a torque directly proportional to the armature current for any one setting of the field current, but when the field current is set for a low-speed condition, there will be more torque for a given armature current than there will be with the same armature current and a field current set for a higher-speed condition. This characteristic requires less current than a corresponding horsepower motor of the constant-speed type during the accelerating period, provided full-field current is maintained during the accelerating period in both cases.

A constant-speed motor is generally used where the motor is run at full speed for a certain period and then stopped by some means, such as an automatic starter. This applies to both reciprocating and to centrifugal pumps.

An adjustable-speed shunt motor is generally used where the motor is kept running and the rate of pumping is varied by changing the speed of the motor with field control by some similar means to that shown in Fig. 2. If the motor speed has a range of approximately two to one by field control, it is not so essential to have an unloader on either a centrifugal- or reciprocating-pump load, because if the motor is started with full field. the armature has twice the torque per ampere which is the equivalent of starting a constant-speed motor on half-load.

The same statements that were made regarding constant-speed shunt motors also apply to slip-ring induction motors with the exception that the number of starting points and resultant current peaks are slightly different as indicated in the table. A slip-ring induction motor should be used where a reciprocating pump is to be started against full load; that is, where no unloader is used. A squirrel-cage induction motor can be used to good advantage for starting centrifugal pumps and fans with or without an unloader or for reciprocating pumps that have unloaders. Because of the advantages of power-factor correction and efficiency which can be gained by the use of synchronous motors, these machines are often used for driving reciprocating and centrifugal pumps and fans equipped with unloaders.

Both manual and automatic control are used for starting and stopping the various kinds of motors previously mentioned. This article will deal only with the automatic types which are most generally used for this kind of service. The table gives in concise form the number of resistor divisions that are generally used for starting and the resultant accelerating-current peaks on the several types of motors when driving the various kinds of pump and fan loads. This table can be used in conjunction with the tables given in the article, "Methods for Determining Resistance Used for Starting Various Types of Motors" in the Nov. 19, 1918, issue of *Power*, which deals with the method of determining the ohmic value per division of the resistor.

Figs. 1 and 5 show the photograph and connections respectively of a starter for a direct-current constant-speed motor. This starter has one line contactor L for connecting the motor to and disconnecting it from the line, and two accelerating contactors A and A' for short-circuiting the two divisions of the resistor. A starter with this number of points can be applied to an equipment with or without an unloader. If it is applied without an unloader, the largest motor it should be used with, as shown in the table, is 10 hp. for a reciprocating or 25 hp. for a centrifugal pump; but if an unloader is used it can be applied to a 45-hp. motor. Detailed descriptions of the operation of this and subsequent panels were given in issues of *Power* during 1916 and 1917, but a further description of the operation of this panel will be included here.

Contactor L is a line switch and is opened and closed by means of its shunt coil. When the control switch is closed contactor L will close, and when the control switch is opened contactor L will open. When contactor L first closes, current will flow from L_1 through R_1-R_2, resistance, the coil of contactor A, through $R2$-$R1$ resistance, the interpole winding and armature of the motor and out to the L_2 line. The coil on contactor A is a series coil which will close this contactor provided the current is within certain specified limits. If the motor is standing still, the initial current from the lines will be above this limit and contactor A will lock out, until the motor has partly accelerated and the current decreased to the specified value. When this contactor closes, it will short-circuit $R2$-$R1$ resistance and therefore the current will flow through the tips of the contactor and through the lower coil on contactor A' instead of through R_2-R_1. When R_2-R_1 section of the resistor is shorted, the current in the line increases and it is this increased value that flows through the lower coil of contactor A', but this contactor, like A, will not close when the current is too high, but will lock out until the current again decreases to the right value. When contactor A' closes, it will short-circuit all the starting resistor and both the series coils of the two contactors, but a shunt holding coil, H, will have its circuit closed through the normally open interlock T on contactor A', and this will be sufficient to hold contactor A' closed. The action of these three contactors will bring the motor from rest to full speed and at all

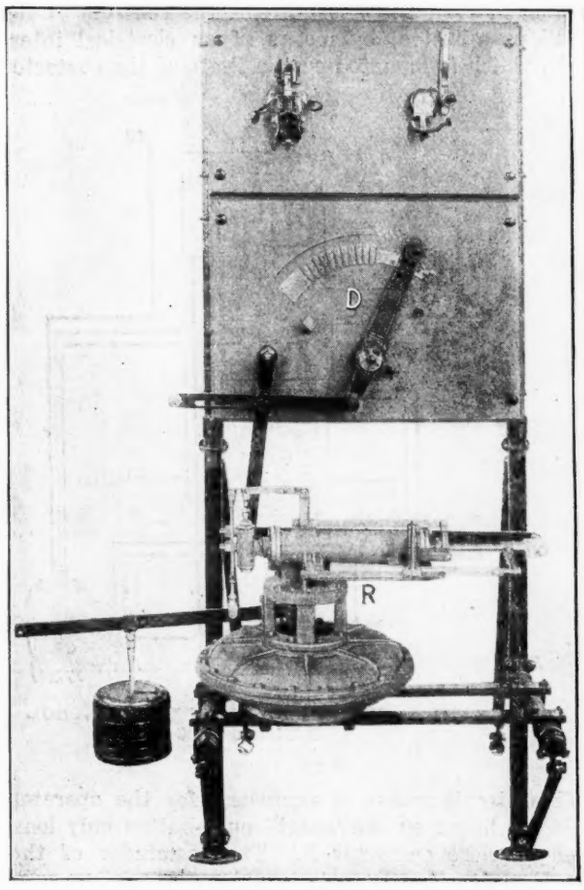


FIG. 2. ADJUSTABLE-SPEED DIRECT-CURRENT MOTOR CONTROLLER

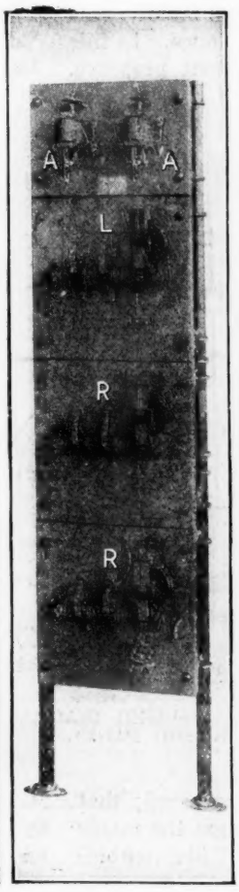


FIG. 3. SLIP-RING MOTOR STARTER

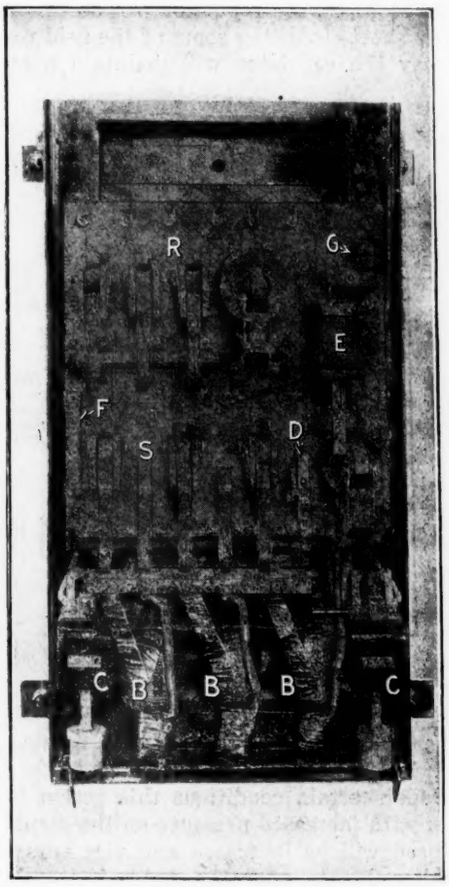


FIG. 4. SQUIRREL-CAGE MOTOR STARTING COMPENSATOR

times keep the line current within prescribed limits as given in the table.

Figs. 2 and 6 show the panel and connections of an adjustable-speed motor starter which is controlled by means of a pressure regulator R. The dial switch D closes the line contactor when in the starting position and then gradually short-circuits the starting resistor. During this period full field is maintained on the motor, but after starting has been completed, the dial can insert resistance in the motor field and thereby increase its speed. The position of this dial is governed by means of the pressure-regulator piston, and it in turn is governed by means of a diaphragm which responds to pressure variation. This pressure (liquid or gas pressure) is generally a function of the motor speed. If the pressure on the diaphragm tends to decrease, the regulator will increase the motor speed by inserting resistance in the field circuit. If the pressure tends to increase, the regulator will decrease the motor speed by short-circuiting some of the field resistance. In this way the regulator will maintain a constant pressure.

Fig. 4 shows an open view of an automatic compensator which is used for starting squirrel-cage induction motors. Figs. 8, 9 and 10 show the connections respectively of this panel when used on a three-phase three-wire, a two-phase three-wire, and a two-phase four-wire circuit. As the photograph and connections show, the panel consists of: One five-pole contactor S for starting the motor; 1 three-pole contactor R for running the motor; 1 current-limit relay E for governing the two contactors S and R; 1 control-circuit fuse F; 2 inverse-time-limit overload relays C and C; and 1 three-coil compensator B. The operation of the panel is as follows:

When the "start" push-button is held down, current will flow from L_1 through the fuse F, the two overload relay tips, the "stop" push-button, the coil of contactof S, the upper tip of the current-limit relay E to L_2, as indicated by the arrowheads. This will close contactor S, which in turn will short-circuit the contacts of the "start" push-button, by means of an electrical interlock D, which is mounted on the shaft of the contactor

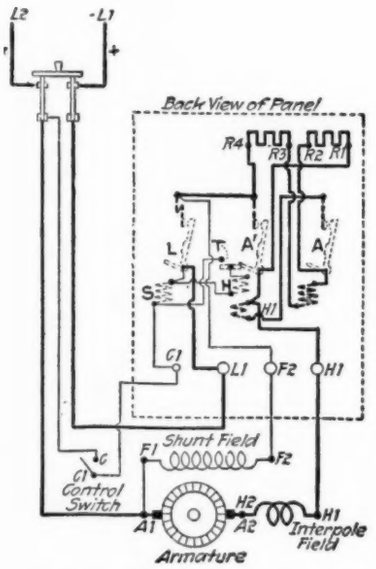


FIG. 5. WIRING DIAGRAM FOR CONTROL PANEL FIG. 1

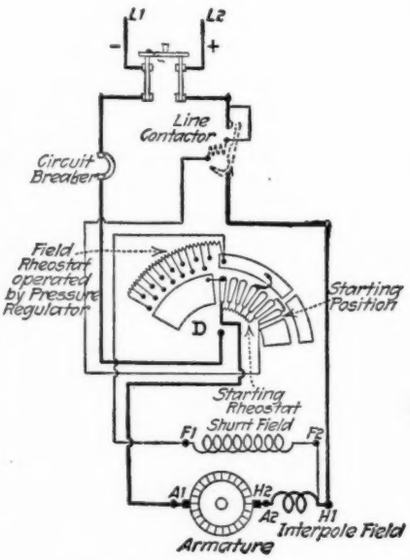


FIG. 6. WIRING DIAGRAM FOR CONTROL PANEL FIG. 2

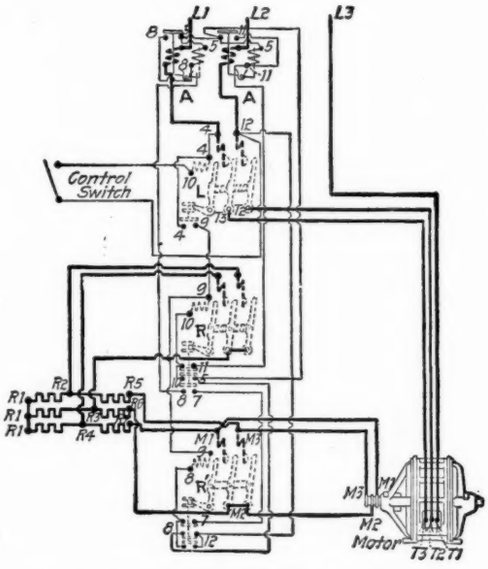


FIG. 7. WIRING DIAGRAM FOR CONTROL PANEL FIG. 3

Under certain conditions this action is reversed; that is, with increased pressure on the diaphragm the motor speed will be increased and vice versa. This combination obtains when the motor is running a stoker and the diaphragm is working from the forced-draft pressure. If the forced-draft is increased, the stoker should increase in speed.

Figs. 3 and 7 show the photograph and connections of an alternating-current slip-ring induction-motor starter. This starter has one contactor L, for connecting the motor to and disconnecting it from the line, and two contactors R and R' for short-circuiting the two divisions of resistance per phase in the rotor circuit. The two relays A and A at the top of the panel govern the closing of the two resistor contactors R and R', and can be adjusted to suit the conditions under which the equipment starts. Referring to the table it is seen that this starter can be used to start a 45-hp. motor when driving a reciprocating pump or a centrifugal pump when they have no unloader; or a 75-hp. when an unloader is used.

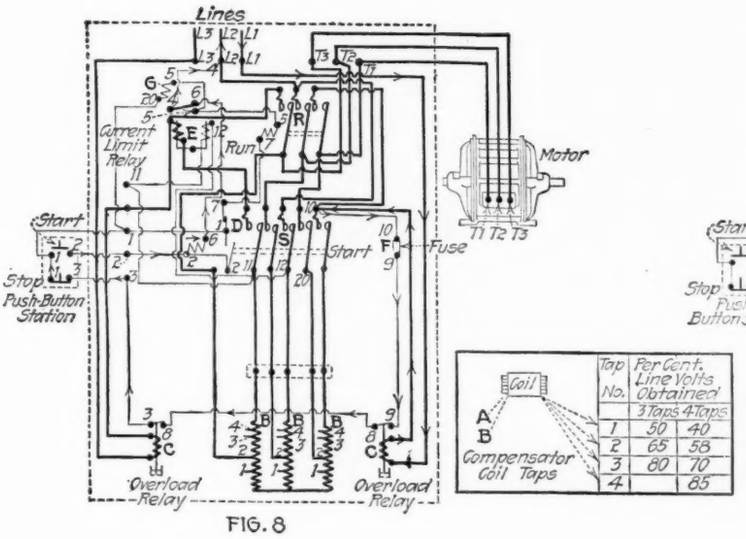
S. This circuit makes it necessary for the operator to hold his finger on the "start" push-button only long enough to close contactor S. The remainder of the cycle of acceleration is entirely automatic. When contactor S closes it connects the three lines L_1, L_2 and L_3 to the top of the compensator coils at the points marked B and also connects the three taps, each marked "2," to the motor. This puts a low voltage on the motor and starts it. The small table between Figs. 8 and 9 shows that if the motor is connected to the taps marked "2," then 58 per cent of line voltage will be applied to the motor when contactor S is closed. If the motor is connected to No. 3 taps, then 70 per cent of line voltage will be put on the motor when contactor S closes. The other taps give values as shown.

The left-hand coil of the current-limit relay E, Fig. 8, has a small number of turns and is connected in series with the line, while the right-hand coil has a large number of turns and is connected across the compensator taps at points marked 11-12 on switch S. Now the plunger in the right-hand coil is heavier than

the plunger in the left-hand coil so that the left plunger is held up against the pivoted contacts marked 4 and 6 by means of the walking beam at the bottom. The right-hand plunger is connected to the walking beam, but the left-hand plunger simply rests on the beam. This means that when contactor *S* closes, the two coils of the relay are energized at the same time, the right-hand coil picking up and pulling the walking beam away from the left-hand core, but the current in the left-hand coil holds the core up against the pivoted contacts 4 and 6, until the motor sufficiently accelerates and lowers the current through this coil to a value where it cannot hold the plunger against gravity. When this happens the pivoted contact is pulled down, which breaks the control across 4-6 and makes contact across 4-5. This opens contactor *S* and closes the coil on contactor *R* through the electrical interlock 7-1 at *D* on contactor *S*. The small coil *G* on relay *E* is connected in multiple with the coil on contactor *R*. When the relay short-circuits the 4-5 contacts on *E*, coil *G* is energized and maintains this pivoted contact in this position all the time the motor is running. When contactor *S* opened it disconnected the compensator from the motor, and when contactor *R* closed it put full voltage on the motor. Before this transfer occurred, the motor had attained approximately 90 per cent speed. To stop the motor, push the stop button and this opens contactor *R* and resets the current-limit relay *E*.

Fig. 9 shows the connection for a two-phase three-wire automatic compensator. The only difference between this and Fig. 8 is that a two-coil instead of a three-coil compensator is used. Fig. 10 is the same as Fig. 9 excepting that four instead of three wires are used in the line circuit.

The automatic compensator provides one starting and one running point. If the speed-torque characteristics of a squirrel-cage induction motor are considered in conjunction with an automatic compensator, it will be noted that one starting point is all that is needed, because the torque increases instead of decreases up to a comparatively high percentage of normally rated speed. Quite frequently a multi-point automatic com-



Tap No.	Per Cent. Line Volts Obtained	
	3 Taps	4 Taps
1	50	40
2	65	58
3	80	70
4		85

FIG. 8

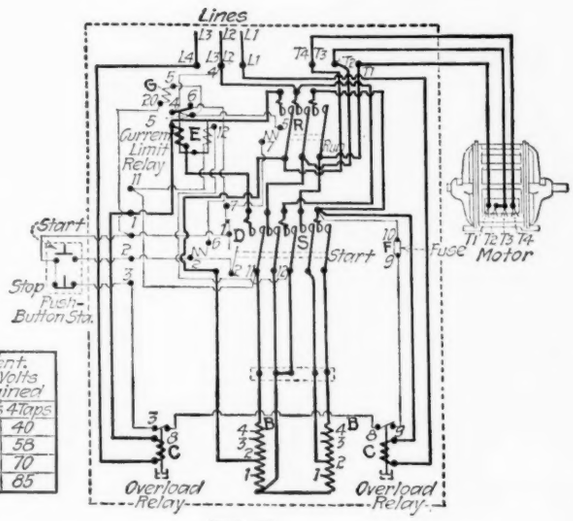


FIG. 9

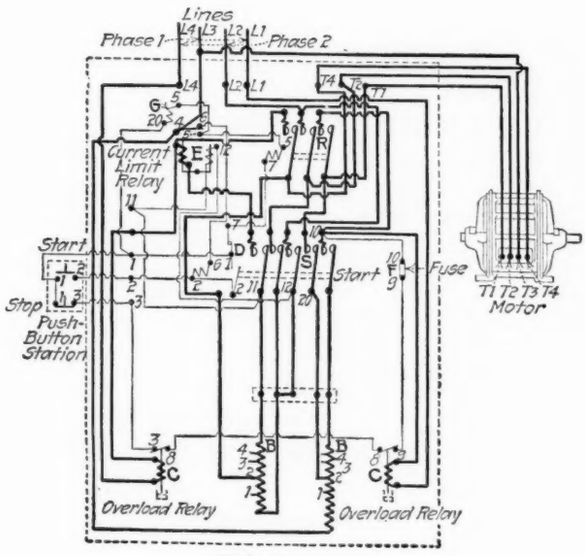


FIG. 10

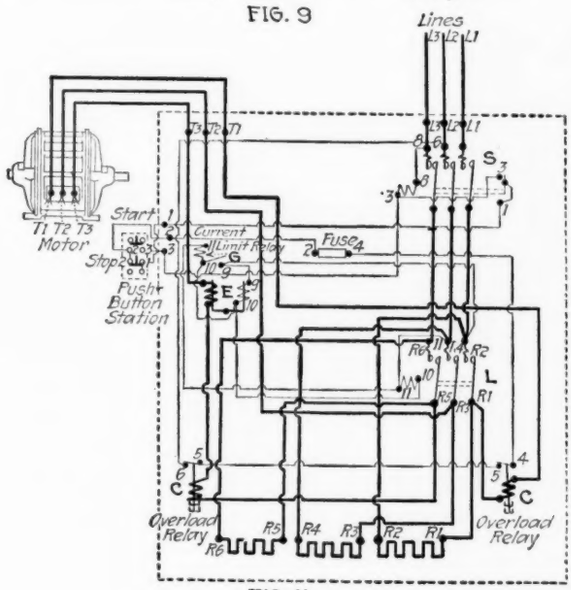


FIG. 11

FIGS. 8 TO 11. WIRING DIAGRAMS OF CONTROL PANELS FOR AUTOMATICALLY STARTING SQUIRREL-CAGE TYPE INDUCTION MOTORS

pensator is asked for, but practically in every instance a one-point compensator will give just as good results. If a one-point automatic compensator will not accomplish the results, then the load should not be started by a squirrel-cage induction motor on partial voltage. In place of the automatic compensator some engineers use a resistance starter, as shown in Fig. 11. This throws the motor on the line through some resistance in each phase, and after the motor accelerates to a specified speed the resistance is short-circuited. This

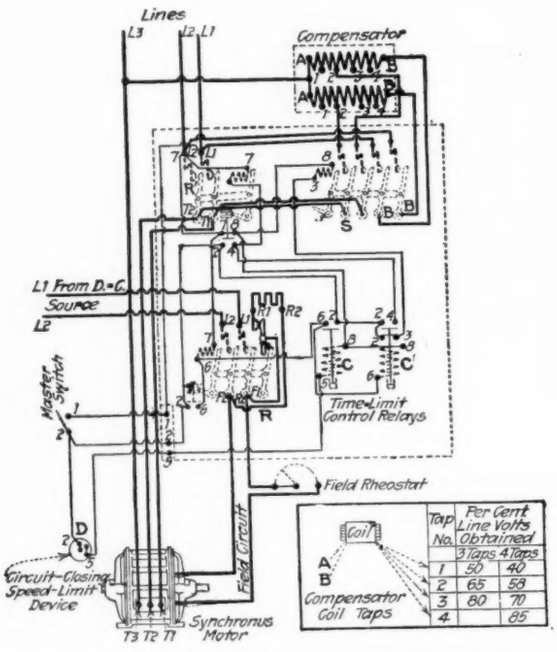


FIG. 12. WIRING DIAGRAM OF CONTROL PANEL FOR STARTING A SYNCHRONOUS MOTOR

arrangement makes a somewhat cheaper starter, but requires more current from the line during starting.

The synchronous motor is not used as generally as the induction motor, but it has an important field. Fig. 12 shows the connections used for starting a low-voltage synchronous motor. It consists of an automatic compensator similar to the one described in the foregoing with the addition of means for handling the field circuit. Instead of the automatic compensator being governed by means of a current-limit relay, it works as follows:

When the master switch is closed, the four-pole contactor *S* closes and puts partial voltage on the motor. When the motor has attained about 90 per cent speed, the centrifugal device *D*, which is attached to the motor shaft, closes the contacts 2-5 and starts the time-limit relays *C* closing. After about five seconds the relay *C* closes its contacts 2-6, which causes contactor *R* to close and puts field current on the motor. This should pull the motor into synchronism if it had not already reached this speed. The closing of the first time-limit relay energized a second time-limit relay *C'*, which after about five seconds simultaneously breaks its contacts 2-3 and closes 2-4 and causes contactor *S* to open and contactor *R'* to close. This action disconnects the compensator from the line and motor and then connects the motor to the line.

In this short article an endeavor has been made to point out the load characteristics of pumps and fans, the different motors that are generally used on pumps and fans, how control should be applied and a few illustrations of control panels. To the person who is not familiar with control problems, some of the recommendations may appear inconsistent, but they have been verified by actual tests.

The shortage of labor in every industry throughout the country has reached a serious stage and, according to statistics, is rapidly growing worse. This and strikes for shorter hours have caused a material lowering of production, to which can be traced in part the high cost of living. Because of strikes 1,105,500 days have been lost in the textile industry alone, in coal mining 220,000 days were lost, clothing factories show a loss of 352,000 days, in the shoe manufacturing industry 77,000 days were lost and on the railroads the losses totaled 38,000 days. Freight cars are lying on sidings and in yards, for lack of men to make necessary repairs. Sufficient labor cannot be found to clean the streets. Telephone companies throughout the country could put 25,000 more women to work. Factories, mills, mines and in fact industries of every description are searching for help. A new supply of unskilled labor is needed to overcome this condition and would probably prove effective in reducing prevailing high prices.

NUMBER OF RESISTOR DIVISIONS SUGGESTED FOR STARTING MOTORS, DRIVING PUMPS AND COMPRESSORS AND THE APPROXIMATE RESULTING MAXIMUM CURRENT PEAKS

Horsepower of Motor	Direct-Current Motors								Alternating-Current Motors											
	Reciprocating Pumps				Centrifugal Pumps and Fans				Reciprocating Pumps					Centrifugal Pumps and Fans						
	Constant-Speed Motors		Adjustable-Speed Motor		Constant-Speed Motors		Adjustable-Speed Motor		Squirrel-Cage Induction Motors		Slip-Ring Induction Motors		Synchro. Motors	Squirrel-Cage Induction Motors		Slip-Ring Induction Motors		Synchro. Motors		
	Without Unloader	With Unloader	Without Unloader	With Unloader	Without Unloader	With Unloader	Without Unloader	With Unloader	Without Unloader	With Unloader	Without Unloader	With Unloader	With Unloader	Without Unloader	With Unloader	Without Unloader	With Unloader	With Unloader		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I	N I		
1–3	1 2.9	1 2.0	1 2.0	1 2.0	1 2.3	1 2.0	1 2.0	1 2.0	Not a good Application	Automatic Compensator	2.5	1 2.8	1 2.0	Automatic Compensator	...	4	2.5	1 2.3	1 2.0	...
5–10	2 2.0	1 2.0	1 2.0	1 2.0	2 1.6	1 2.0	1 2.0	1 2.0			2.5	1 3.0	1 2.0		...	4	2.5	1 2.3	1 2.0	...
15–25	3 1.8	2 1.4	2 1.4	1 2.0	2 1.7	2 1.4	1 2.0	1 2.0			2.5	2 2.0	1 2.2		...	4	2.5	2 1.6	1 2.2	...
30–45	4 1.6	2 1.6	2 1.6	2 1.6	3 1.5	2 1.6	2 1.6	2 1.6			2.0	2 2.2	2 1.5		...	3	2.0	2 1.9	2 1.5	...
50–75	4 1.7	3 1.2	3 1.2	2 1.6	3 1.7	3 1.2	2 1.6	2 1.6			2.0	3 1.9	2 1.6		...	3	2.0	3 1.8	2 1.6	...
80–125	5 1.6	3 1.3	3 1.3	3 1.3	4 1.5	3 1.3	3 1.3	3 1.3			2.0	4 1.8	3 1.2		...	3	2.0	3 1.7	3 1.2	...
135–275	6 1.6	4 1.1	4 1.1	4 1.1	4 1.6	4 1.1	4 1.1	4 1.1			2.0	5 1.7	3 1.3		...	4	2.0	4 1.6	3 1.3	...
300–500	7 1.5	4 1.2	4 1.2	4 1.2	4 1.7	4 1.2	4 1.4	4 1.2			2.0	6 1.6	4 1.2		...	3	2.0	4 1.7	4 1.2	...

NOTE—*N* equals number of resistor divisions suggested for starting the motor; *I*, when multiplied by the rated motor current, equals the maximum current peaks, resulting from the use of the suggested value of *N*.

Measuring Flow of Fluids

By JACOB M. SPITZGLASS
Vice President, Republic Flow Meters Company, Chicago

Relation between velocity and pressure. Obtaining differential pressure by pitot tube, venturi tube, nozzle tube or an orifice plate. A general formula applicable to all the devices mentioned and tables making it simple to obtain quantity flow from the differential pressure readings of a gage or manometer.

WHENEVER a moving body is stopped from its motion or brought to rest, the kinetic energy contained in that body, due to its velocity, is converted into another form of energy, which, in the case of fluids, results in pressure. This pressure, created by the force of stopping the motion of fluid, is called the "velocity pressure," which, when added to the initial or "static pressure," due to the physical condition of the fluid, forms the final, or "dynamic pressure."

The "dynamic pressure" is obtained when a tube is inserted at any fixed point of a stream with its open end pointing against the flow and the other end is balanced by some stationary force, such as a column of water or mercury.

By inserting a similar tube near the first one, but with its open end pointing at right angles to the flow, the pressure created in it will be equal to the static pressure only, if the velocity of the fluid does not produce any effect upon the opening of the tube.

Connecting the static tube to the upper end of the dynamic column virtually subtracts the static pressure from the dynamic and thus gives directly the differential or velocity pressure equivalent to the flow.

In other cases a differential pressure is created by the introduction of a contracted area in the stream of the fluid for the purpose of converting a certain amount of potential energy existing in the form of pressure into an equivalent amount of kinetic energy resulting from the increased velocity of the fluid.

In all such cases there exists a definite relation between the differential pressure thus obtained and the velocity of the fluid that is to be measured. The flow of any fluid can be measured conveniently and accurately by converting its velocity, which cannot be measured directly, into pressure, which can be easily measured by a column of liquid or a gage.

For practical purposes the differential or velocity pressure in a given line may be obtained, either directly by balancing the difference between the dynamic and static sides of a pitot tube inserted in the line, as shown in Figs. 1, 2 and 3; or indirectly, by balancing the difference between the high- and low-pressure sides of a venturi tube, Fig. 4, nozzle tube, Fig. 5, or an orifice plate, Fig. 6.

In the case of a pitot tube it should be noticed that the differential column balancing the difference in pressure represents the flow, or motion, existing at the given section of the line. With a venturi tube, nozzle tube or orifice plate, the column obtained represents the change of motion produced by the artificial obstruction of the passage at the given section of pipe.

The pitot tube is employed generally in cases where the minimum flow in the pipe is sufficient to make a perceptible difference in pressure for operating the measuring device, and the maximum flow is not over the range of the given device. The venturi tube or orifice is better adapted for cases where the flow existing in the line is either too low or too high for the range of pressure difference in the measuring device. When a venturi tube or orifice is used, the change of motion or the difference in kinetic energy between original and final flow, can be made to suit by varying the size of the restricted passage in the line.

Two distinct forms of pitot tube are generally used—one designated as a combined impact tube of the form

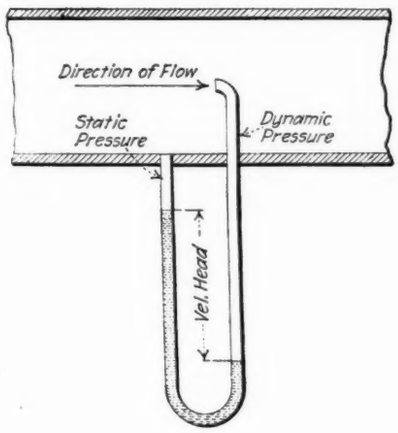


FIG. 1. ILLUSTRATING SIMPLE PITOT TUBE

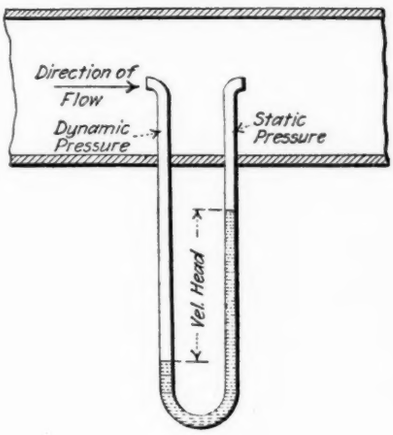


FIG. 2. DIFFERENTIAL PITOT TUBE ANOTHER FORM OF

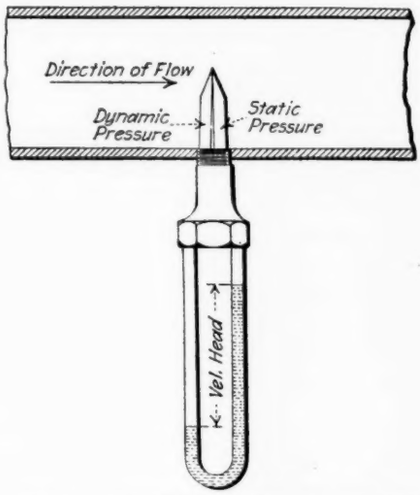


FIG. 3. SPECIAL FORM OF DIFFERENTIAL PITOT TUBE

shown in Fig. 1, and the other as the differential tube shown in Figs. 2 and 3. In the combined impact tube one opening is pointed against the flow to receive the dynamic pressure. The other opening is at right angles to the flow, for the purpose of receiving the static pressure only. As a matter of fact, the opening pointed against the flow receives the true dynamic pressure, because the flow is entirely stopped at the point of impact, transmitting the full velocity pressure to the connections of the U-tube. On the other hand, the opening at right angles to the flow does not always receive the true static pressure, due to the effect of aspiration or siphoning produced by the flow in the line.

In the differential tube the two openings are pointed in opposite directions; one is made to receive the dynamic pressure, and the other is acted upon by the suction of the flow, so that the differential column in the U-tube represents impact plus suction. The differential tube is generally preferred for practical purposes. In the first place the effect of suction in the direction of the flow is more positive than the effect of siphoning at right angles to the flow. In the second place the suction produced by the flow magnifies the differential column corresponding to a given velocity of the fluid, which in turn facilitates the operation of the measuring device and permits of a larger scale that can be read with accuracy.

With any one of these various devices a differential pressure is obtained, and starting from this reading the quantity of flow in pounds, gallons or cubic feet per unit of time may be calculated. It is convenient to base all the calculations of flow upon the differential column measured in inches of water. The U-tube of the measuring device may be filled with mercury and the actual differential pressure carried by the height of the mercury column; but the effective height and all the measurements of flow are based on the equivalent column in inches of water. When mercury is used with an ordinary U-tube manometer, an inch of mercury is equivalent to 13.6 in. of water when the measurement is made on air or gas. When measuring steam or water, the equivalent is 12.6 in. of water for one inch of mercury. When single-tube manometers or similar devices are used for balancing the flow, the effective height may be conveniently determined by the method shown diagrammatically in Fig. 7. In such cases the ratio of the water column to the mercury column will

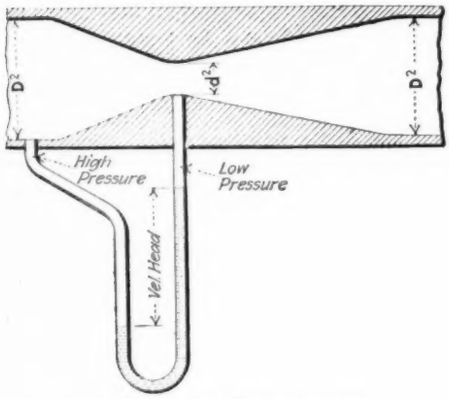


FIG. 4. VENTURI TUBE

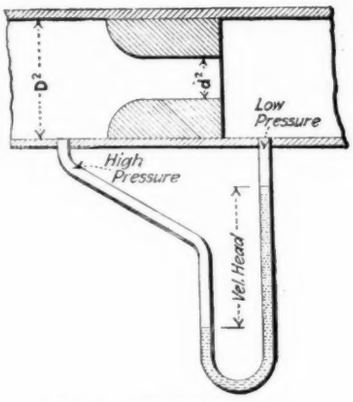


FIG. 5. NOZZLE TUBE

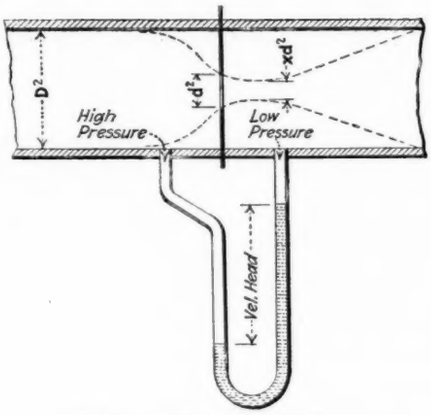


FIG. 6. ORIFICE PLATE

TABLE I. FLOW OF WATER
(Assumi g D^2 = i ci c lar inch, C = 1)

Temp., Deg. F.	Values of K — Pounds per Hour — 1 in. H_2O	1 in. HgO	— Gal. per Hour — 1 in. H_2O	1 in. Hg.
60	2.838	10.070	340.5	1.208
70	2.837	10.065	340.7	1.209
80	2.835	10.060	341.0	1.210
90	2.833	10.055	341.3	1.211
100	2.830	10.045	341.6	1.213
110	2.827	10.035	342.0	1.214
120	2.824	10.025	342.4	1.215
130	2.820	10.015	342.8	1.216
140	2.816	10.000	343.3	1.218
150	2.812	9.985	343.	1.220
160	2.807	9.965	344.3	1.222
170	2.802	9.945	344.9	1.224
180	2.797	9 25	345.5	1.226
190	2.792	9 905	346.1	1.229
200	2.786	9.885	346.8	1.231
210	2.781	9.865	347.5	1.234
220	2.776	9. 50	348.2	1.236
230	2.770	9.830	348.9	1.238
240	2.764	9.810	349.7	1.241
250	2.758	9.790	350.5	1.244
260	2.751	9.765	351.3	1.247
270	2.743	9.740	352.1	1.250
280	2.735	9.710	353.0	1.253
290	2.727	9.680	354.0	1.257
300	2.719	9.550	355.2	1.261

NOTE—1 in. of mercury under water equals 12.6 in. of water head.

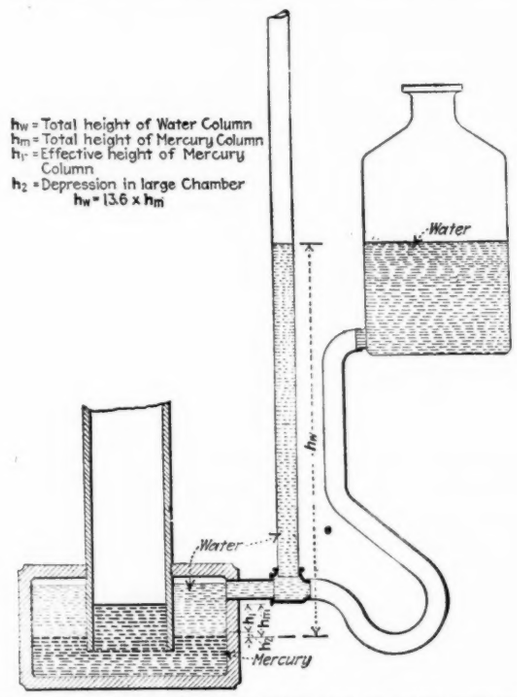

hw = Total height of Water Column
hm = Total height of Mercury Column
h1 = Effective height of Mercury Column
h2 = Depression in large Chamber
hw = 13.6 x hm
Water
Water
Mercury

FIG. 7. BALANCING MERCURY AND WATER COLUMNS

depend upon the relation of the areas in the two chambers of the gage.

It is also convenient to adopt the circular unit of area as the determination of constants for a given measuring device is facilitated. The flow per circular unit is multiplied by the diameter squared, to obtain the quantity, in the same manner as circular mills are used in electrical measurements.

From the usual formula expressing the general relations between pressure and velocity of fluids, one general formula may be derived that will be applicable to all the devices shown and for the various mediums measured. In its simplest form, giving results in pounds per hour, this formula is as follows:

$$G = (359.3\ C\ D^2\ \sqrt{S}) \times \sqrt{h}$$

where

G = Weight of flow in pounds per hour;
C = Coefficient of discharge, or the ratio of the actual to the theoretical amount of flow;
D^2 = Diameter of pipe squared in inches;
S = Density of fluid in the pipe in pounds per cubic foot;
h = Differential column in inches of water.

Each of the factors indicated by the letters in the formula are easily obtainable except the coefficient C, which varies for each type of device illustrated. To make calculation more simple, however, a number of tables based on this formula have been worked out, covering the flow of water, steam, gas and air for a wide variation of pressure or temperature. In these tables it was necessary to assume that the value of D^2, $\sqrt{h}$ and C each equal 1, so that the quantity designated by K is equal to $359.3\ \sqrt{S}$. In a specific problem, then, it is necessary only to take the value of K given in the table and multiply by the true values of the three quantities mentioned. The diameter of the pipe D is available, the head h is given by the measuring device, so that the coefficient C is the only factor needing further attention.

For the combined impact tube, Fig. 1, with the dynamic opening placed in the center of the flow, C has an average value of 0.90; for the differential tube of the form shown in Figs. 2 and 3 the value of C varies from 0.73 to 0.80. For the venturi tube of Fig. 4 the value of C depends on the ratio of the throat section d^2 to the pipe section D^2. The curves of Fig. 8 cover a wide range, showing the value of C corresponding to a given ratio of throat to pipe sections.

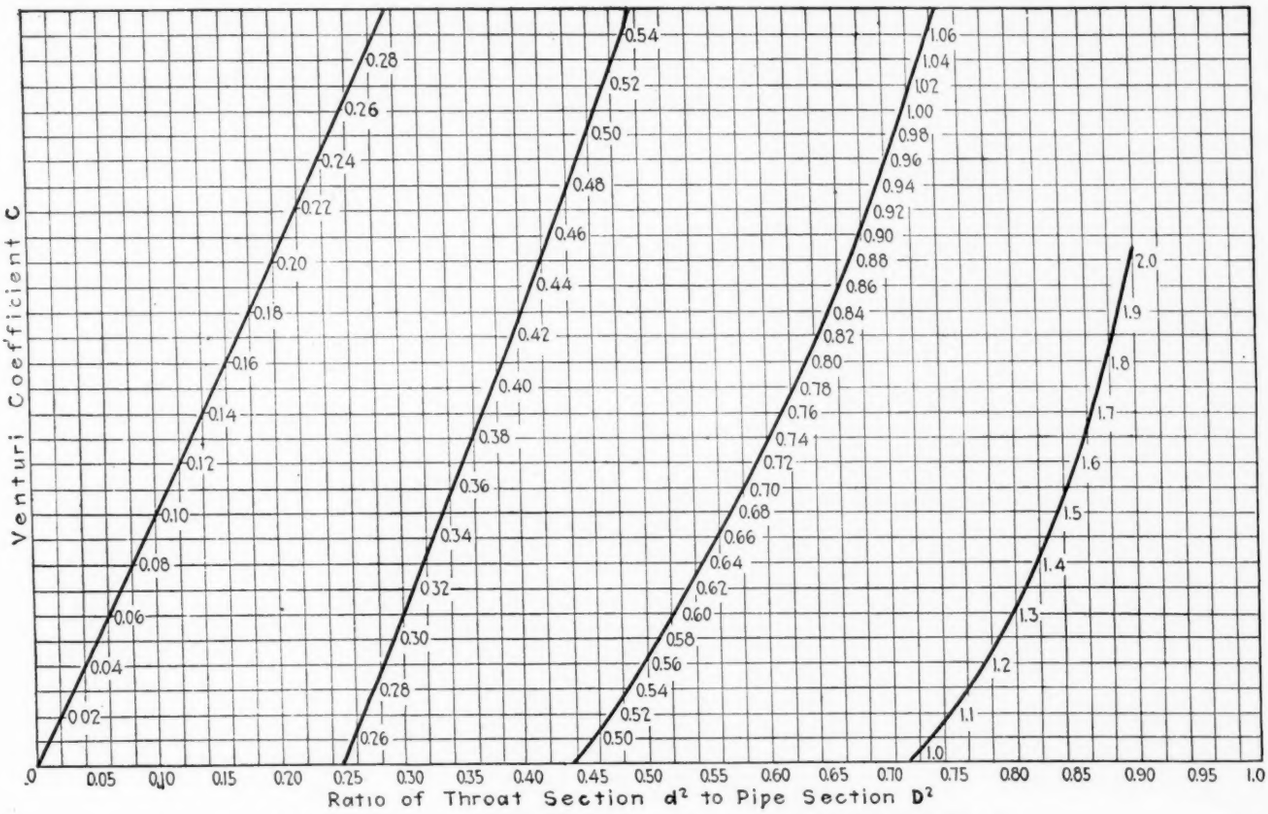


FIG. 8. VENTURI COEFFICIENT C AS RELATED TO PIPE SECTION D^2

In the nozzle tube shown in Fig. 5 the coefficient varies with the roundness of the inlet and the size of the tube, so that it is necessary to test each tube in the same way the ordinary nozzles are being calibrated for measuring the flow of water.

In Fig. 6 is shown the general form of orifice connections. The orifice differs from the nozzle tube in that the approach of the flow is fully contracted by the sharp edge of the plate. This results in an even amount of friction loss, and therefore the effectiveness of the orifice as a means of obtaining differential pressure is the same for all orifices of this kind.

The flow through the orifice takes the same form as through a venturi, except that the smallest section corresponding to the throat of the venturi is formed after the fluid passes through the orifice. The orifice coefficient, therefore, involves an additional factor over the venturi tube in that the contracted area is smaller than

TABLE II. FLOW OF SATURATED STEAM

(Assuming D^2 = 1 circular inch, C = 1)

Absolute Pressure Lb.	Gage Pressure Lb.	Corres. Temp. Deg. F.	Values of K — Pounds per Hour 1 in. H_2O	1 in. Hg.
14.7	0	212.0	69.38	246.2
15.7	1	215.3	71.57	254.1
16.7	2	218.4	73.73	261.8
17.7	3	221.5	75.81	269.2
18.7	4	224.3	77.72	276.0
19.7	5	227.0	79.62	282.7
20.7	6	229.7	81.45	289.2
21.7	7	232.3	83.25	295.5
22.7	8	234.8	85.01	301.8
23.7	9	237.1	86.77	308.0
24.7	10	239.4	88.46	314.0
25.7	11	241.6	90.11	319.8
26.7	12	243.7	91.73	315.6
27.7	13	245.8	93.27	331.3
28.7	14	247.8	94.85	336 9
29.7	15	249.8	96.40	342.3
30.7	16	251.7	97.87	347.6
31.7	17	253.5	99.38	352.8
32.7	18	255.3	100.85	358.2
33.7	19	257.0	102.33	363.3
34.7	20	258.8	103.69	368.2
39.7	25	266.8	110.28	392.0
44.7	30	274.0	116.70	414.3
49.7	35	280.6	122.70	435 7
54.7	40	286.6	128.34	455.8
59.7	45	292.3	133.70	474.5
64.7	50	297.7	138.9	492.5
69.7	55	302.6	143.8	510.5
74.7	60	307.3	148.6	527.5
79.7	65	311.9	153.1	543.5
84.7	70	316.0	157.6	559.5
89.7	75	320.0	162.0	575.5
94.7	80	324.0	166.1	590.5
99.7	85	327.8	170.2	604.5
104.7	90	331.2	174 2	618.5
109.7	95	334.6	178.1	632.5
114.7	100	337.8	182.0	646.0
119.7	105	341.2	185.7	659.0
124.7	110	344.4	189.3	672.0
129.7	115	347.4	192.9	685.0
134.7	120	350.2	196.4	697.5
139.7	125	352.9	199.8	709.5
144.7	130	355.7	203.2	721.5
149.7	135	358.5	206.5	733.0
154.7	140	361.0	209.8	744.5
159.7	145	363.5	213.0	756.0
164.7	150	365.9	216.2	767.5
169.7	155	368.4	219.3	778.5
174.7	160	370.8	222.4	789.5
179.7	165	373.0	225 4	800.0
184.7	170	375.2	228.4	810.0
189.7	175	377.3	231.4	822.0
194.7	180	379.5	234.3	832.0
199.7	185	381.7	237.2	842.0
204.7	190	383.8	240.0	952.0
209.7	195	385.9	242.6	861.5
214.7	200	387.9	245 6	871.5
219.7	205	389.8	248.	881.0
224.7	210	391.7	251.0	891.0
229.7	215	393.7	253.6	900.5
234.7	220	395.5	256.3	910.0
239.7	225	397.4	259.1	920.0
244.7	230	399.2	261.6	929.0
249.7	235	400.9	264.3	938.0
254.7	240	402.7	266.7	947.0
259.7	245	404.5	269.4	965.0
264.7	250	406.2	271.7	956.0
269.7	255	407.8	274.3	974.0
274.7	260	409.4	276.7	983.0
279.7	265	411.0	279.3	992.0
284.7	270	412.6	281 6	1,000.0
289.7	275	414.3	284 1	1,008.0
294.7	280	415.8	286.3	1,016.0
299.7	285	417.4	288.8	1,024.0
304.7	290	418.9	291.3	1,032.0
309.7	295	420.4	293.4	1,040.0
314.7	300	422.0	295.9	1,048 0

NOTE—1 in. of mercury under water equals 12.6 in. of water head.

TABLE III. CORRECTION FACTORS FOR SUPERHEATED STEAM

Degrees of Superheat	Factor	Degrees of Superheat	Factor
0	1.000	130	0.907
10	0.991	140	0.901
20	0.982	150	0.895
30	0.974	160	0.89
40	0.966	170	0.885
50	0.958	180	0.88
60	0.951	190	0.875
70	0.944	200	0.87
80	0.938	250	0.847
90	0.931	300	0.826
100	0.925	400	0.789
110	0.919	500	0.757
120	0.913		

TABLE IV. FLOW OF GAS AND AIR

(Assuming D^2 = 1 circular inch, C = 1)

Values of K for air at standard temperature of 60 deg. F. For gas of specific gravity other than unity, divide proper factor from table by the square root of the specific gravity of the gas referred to air.

Abso. Press., Lb.	Gage Press., Lb.	Values of K — Std. Cu.Ft. per Hour 1 in. H_2O	1 in. Hg.
14.7	0	1,301	4,800
15.7	1	1,344	4,960
16.7	2	1,385	5,110
17.7	3	1,426	5,260
18.7	4	1,465	5,410
19.7	5	1,505	5,555
20.7	6	1,542	5,695
21.7	7	1,579	5,830
22.7	8	1,615	5,960
23.7	9	1,650	6,090
24.7	10	1,685	6,215
25.7	11	1,718	6,540
26.7	12	1,750	6,460
27.7	13	1,781	6,575
28.7	14	1,812	6,690
29.7	15	1,843	6,805
30.7	16	1,874	6,915
31.7	17	1,904	7,025
32.7	18	1,934	7,135
33.7	19	1,964	7,245
34.7	20	1,994	7,355
39.7	25	2,137	7,880
44.7	30	2,264	8,360
49.7	35	2,388	8,820
54.7	40	2,511	9,270
59.7	45	2,619	9,660
64.7	50	2,726	10,050
69.7	55	2,826	10,430
74.7	60	2,924	10,790
79.7	65	3,022	11,150
84.7	70	3,120	11,510
89.7	75	3,210	11,840
94.7	80	3,297	12,160
99.7	85	3,383	12,480
104.7	90	3,466	12,800
109.7	95	3,550	13,090
114.7	100	3,628	13,380
119.7	105	3,706	13,670
124.7	110	3,784	13,960
129.7	115	3,861	14,250
134.7	120	3,936	14,530
139.7	125	4,011	14,800
144.7	130	4,081	15,060
149.7	135	4,150	15,310
154.7	140	4,218	15,560
159.7	145	4,284	15,810
164.7	150	4,350	16,050
169.7	155	4,416	16,290
174.7	160	4,480	16,530
179.7	165	4.543	16,770
184.7	170	4,606	17,000
189.7	175	4,668	17,230
194.7	180	4,730	17,460
199.7	165	4,791	17,680
204.7	190	4,852	17,900
209.7	195	4,910	18,120
214.7	200	4,968	18,330
219.7	205	5,026	18,540
224.7	210	5,084	18,750
229.7	215	5,142	18,960
234.7	220	5,198	19,170
239.7	225	5,253	19,380
224.7	230	5,307	19,590
249.7	235	5,361	19,800
254.7	240	5,414	20,000
259.7	245	5,467	20,190
764.7	250	5,520	20,380
269.7	55	5,572	20,560
274.7	260	5,623	20,740
279.7	265	5,673	20,920
284.7	270	5,722	21,100
289.7	275	5,771	21,280
294.7	280	5,820	21,460
299.7	285	5,869	21,640
304.7	290	5,918	21,820
309.7	295	.....	.....
314.7	300	6,012	22,180

the area of the orifice section. This factor is determined experimentally for each ratio of orifice diameter to pipe diameter, and the given size of the pipe.

The following examples will demonstrate the use of the tables and the solution of problems in measuring the flow of fluids in pipes:

Example 1—Pitot tube measuring flow of water:

internal diameter of tube, $D = 6$ in.; coefficient of tube, $C = 0.80$; differential column, $h = 1$ in. of mercury; temperature of water, 200 deg. F.

From Table I, opposite 200 deg. F., $K = 9{,}885$ lb. per hour, or 1,231 gal. per hour.

$9{,}885 \times (6)^2 \times 0.80 \times \sqrt{1} = 284{,}688$ lb. per hr.

$1{,}231 \times (6)^2 \times 0.80 \times \sqrt{1} = 35{,}453$ gal. per hr.

The solution obtained for one inch of mercury differential can be applied to any other height simply by multiplying the quantity by the square root of the given height of the mercury column, thereby avoiding the repetition of multiplying the other factors which are constant for the same conditions of flow.

Example 2—Venturi tube measuring flow of water: internal diameter of pipe, $D = 3$ in.; diameter of throat, $d = 1$ in.; differential column, $h = 10$ in. of mercury; temperature of water, 60 deg. F.

TABLE V. TEMPERATURE CORRECTION FACTORS FOR GAS AND AIR

Temp., Deg. F.	Factor	Temp., Deg. F.	Factor
0	1.063	230	0.868
10	1.052	235	0.865
20	1.041	240	0.862
30	1.030	245	0.859
40	1.020	250	0.856
50	1.009	255	0.853
60	1.000	260	0.850
65	0.996	265	0.847
70	0.991	270	0.844
75	0.986	275	0.841
80	0.981	280	0.838
85	0.977	285	0.836
90	0.972	290	0.833
95	0.968	295	0.830
100	0.964	30	0.827
105	0.959	350	0.802
110	0.956	400	0.778
115	0.951	450	0.756
120	0.947	500	0.736
125	0.943	550	0.718
130	0.939	600	0.700
135	0.935	650	0.684
140	0.931	700	0.670
145	0.927	750	0.656
150	0.923	800	0.643
155	0.920	850	0.630
160	0.916	900	0.619
165	0.912	950	0.607
170	0.909	1,000	0.597
175	0.905	1,050	0.587
180	0.902	1,100	0.577
185	0.898	1,150	0.568
190	0.895	1,200	0.56
195	0.891	1,250	0.552
200	0.883	1,300	0.544
205	0.885	1,350	0.536
210	0.881	1,400	0.529
215	0.878	1,450	0.522
220	0.875	1,500	0.511
225	0.872		

First obtain venturi coefficient as follows:

$$\frac{d^2}{D^2} = \left(\frac{1}{3}\right) = 0.111$$

From Fig. 8, opposite the ratio, 0.11, read the coefficient, $C = 0.109$. From Table I, opposite 60 deg. F., $K = 10{,}070$ lb. per hour, or 1,208 gal. per hour.

$10{,}070 \times (3)^2 \times 0.109 \times \sqrt{10} = 31{,}217$ lb. per hr.

$1{,}208 \times (3)^2 \times 0.109 \times \sqrt{10} = 3{,}745$ gal. per hr.

Example 3—Pitot tube measuring flow of steam; internal diameter of pipe, $D = 10$ in.; coefficient of tube, $C = 0.90$; differential column, $h = 1$ in. of mercury; steam pressure, 150 lb. gage.

From Table II, opposite 150 lb. pressure, $K = 767.5$ lb. per hour.

$767.5 \times 10^2 \times 0.90 \times \sqrt{1} = 69{,}075$ lb. per hr.

Example 4—Venturi tube measuring flow of air: internal diameter of pipe, $D = 16$ in.; diameter of throat, $d = 8$ in.; differential column, $h = 4$ in. of water; static pressure, 100 lb. gage; air temperature, 120 deg. F.

Obtain venturi coefficient as follows:

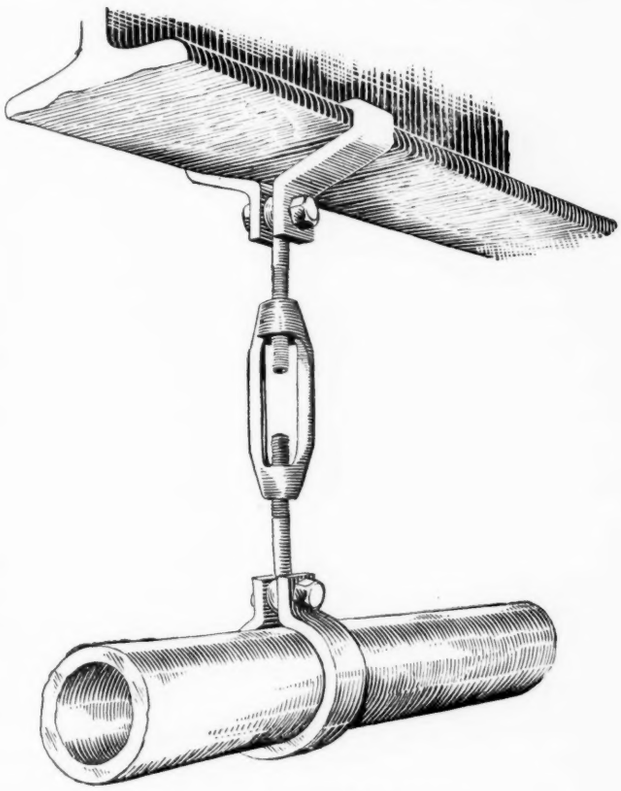
$$\frac{d^2}{D^2} = \left(\frac{8}{16}\right)^2 = 0.25$$

From Fig. 8, opposite ratio 0.25, read coefficient, $C = 0.253$. From Table IV, opposite 100 lb. per hour, $K = 3{,}628$ standard cubic feet per hour. From Table V, the correction factor at 120 deg. F. is 0.947.

$3{,}628 \times 0.947 \times (16)^2 \times 0.253 \times \sqrt{4} = 445{,}047$ standard cu.ft. per hr.

Standard Pipe-Hanger Data

Very little has been published regarding pipe hangers. The accompanying figure and table give some interesting data regarding hangers from 2 in. up to 24 in. in which is incorporated the various dimensions and the safe load each will carry.



STANDARD PIPE HANGER

DIMENSIONS OF PIPE-HANGER PARTS

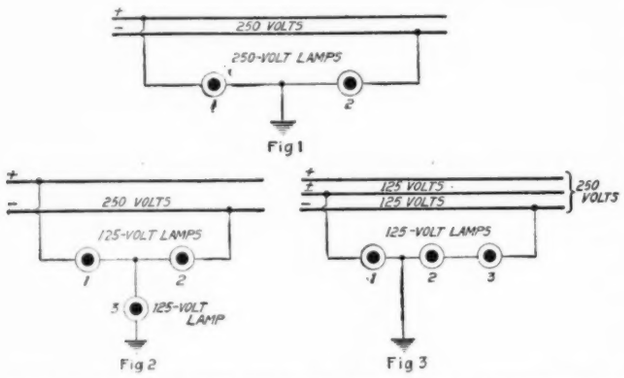
Pipe Size, In.	Pipe Thick., In.	Band Width, In.	Clamp Thick., In	Clamp Width, In.	Rod, Diam., In.	Bolts Band, In.	Bolts Clamp, In.	Safe Load, Lb.	Length ½ Band, In.
2						½x2	½x2½	1,160	6
2½						½x2	½x2½	1,160	7
3						½x2	½x2½	1,160	8
3½						½x2	½x2½	1,160	9
4						½x2	½x2½	1,870	10½
4½						½x2	½x2½	1,870	11
5		2		2		½x2	½x2½	1,870	13
6		2		2		½x2½	½x2½	1,870	14
7		2		2		½x2½	½x3	2,830	16
8		2		2½		½x2½	½x3½	2,830	18
9		2		2½		½x2½	½x3½	3,940	20
10		2		2½		½x3	½x3½	3,940	22
12		2½		2½	1	½x3½	1 x3½	5,180	25
14		2½		2½	1¼	1 x3½	1¼x3½	6,510	27
15		2½		2½	1¼	1 x3½	1¼x3½	6,510	30
16		3		3	1¼	1¼x3½	1¼x4	6,510	33
18		3		3	1¼	1¼x4	1¼x4	8,410	35
20		3		3	1¼	1¼x4	1¼x4½	8,410	37
22		3		3	1¼	1¼x4½	1¼x4½	8,410	39
24		3		3	1¼	1¼x4½	1¼x4½	8,410	42

Ground Detectors for Direct-Current and Alternating-Current Circuits

By FRANK GILLOOLY

SOME of the schemes for utilizing lamps to indicate grounds on low-voltage circuits are illustrated in Figs. 1, 2 and 3. In Fig. 1, both lamps are 250-volt units, and when both sides of the system are ungrounded the lamps burn at half brilliance. Should a ground occur on the positive side, lamp 1 will go out and lamp 2 come to full brilliance; with a negative ground, lamp 2 will go out and lamp 1 become bright. Should either lamp burn out or work loose in its socket, both lamps will go out.

In Fig. 2 lamps 1 and 2 are at half brilliance and lamp 3 dead while the system is ungrounded. With



FIGS. 1 TO 3. LAMP GROUND DETECTOR CONNECTIONS ON LOW-VOLTAGE CIRCUITS

a ground on either side of the system the lamp connected to that conductor will go out while the lamp of the opposite conductor, together with lamp 3, will become bright. In this scheme all lamps could be 125-volt ones; then lamps 1 and 2 would burn at full candlepower. Lamp 3, which usually has a red bulb, is conspicuously situated on the switchboard. With this layout should lamp 1 or 2 burn out the circuit will be opened and all lamps will go out, provided there is no ground on the system.

A scheme of lamp connections that will select a ground on any conductor of a three-wire system is given in Fig. 3. This method employs three 125-volt lamps connected in series between the neutral and negative conductors of the system, with the ground connection made between the lamp connected to neutral and the two connected to negative. A chart that shows the indications for each kind of ground is usually located near the lamps for the operator's guidance. Normally, all the lamps burn at one-third brilliance, since three of them are connected in series on a 125-volt circuit. On a positive ground all three lamps will come to full brilliance. On a neutral ground, lamp 1 will go out and lamps 2 and 3 come to one-half brilliance. On a negative ground, lamp 1 will be bright and lamps 2 and 3 will be dead.

In general, the lamps should be so definitely marked that there can be no doubt as to their indications. Where lamps are merely marked "Positive" and "Negative," operators become confused as to whether the positive lamp indicates a positive ground when it is bright or when it is dead. If the lamps are marked "Positive Bus" and "Negative Bus," the attendant knows that the ground is on the bus whose lamp is dead; or, if they are marked "Positive Ground" and "Negative Ground"—with the lamp marked positive connected to the negative bus and vice versa—he knows, when the lamp marked positive is bright, that the system has a positive ground.

The commonest use made of ground lamps in the alternating-current generating station is on the direct-current excitation and control systems, where they become highly essential. The direct-current field is the heart of the synchronous generator. A breakdown of the alternator's field winding means that until the unit can be spared for the period required to rewind the field, it must be separately excited; since a ground of opposite polarity elsewhere on the system would shunt out part of the field winding and reduce the capacity of the unit, if it did not burn out the winding. Ordinarily, the operating energy for the oil circuit-breakers, rheostats and governor motors, is taken from the excitation system; and with another ground on the system, the failure of the insulation of the operating device of any of this apparatus might cause it to function and open or close. In the case of motor-operated oil switches, such a double ground may cause the switch to trip out or even to successively open and close until its entire control circuit is killed.

Lamps are also used with transformers to indicate the existence of grounds on high-voltage circuits.

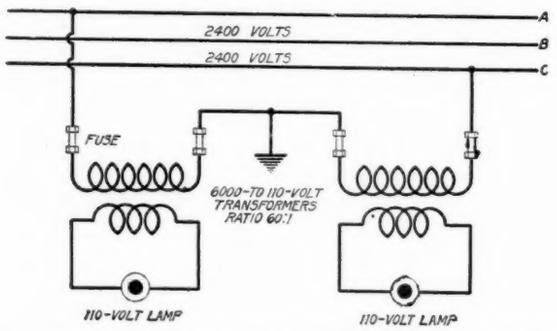


FIG. 4. GROUND LAMPS CONNECTED TO TRANSFORMERS ON TWO-PHASE SYSTEM

Fig. 4 shows the connections for a 2,400-volt two-phase system. The two transformers are connected in series across phases and grounded on the connection between them, each transformer having on its primary winding one-half the cross-phase voltage, or $\frac{\sqrt{2} \times 2400}{2} = 1{,}700$ volts. The transformers are regular 6,600 to 110-volt units, having a 60 to 1 ratio, so that normally each lamp burns on 28 volts and is barely lighted. With a ground on the *A* conductor of the system, that lamp will go out and the *C* lamp burn on 56 volts. A ground on *C* wire will put out the

C lamp and throw the *A* lamp on 56 volts. With a ground on *B* wire both transformers will have 2,400 volts on their primaries and 40 volts on their lamps.

Electrostatic ground detectors are really electrostatic voltmeters which indicate the existence of a ground on the system. Both the electrostatic detectors and the transformer-fed ground lamps will give an indication on any unbalanced voltage condition,

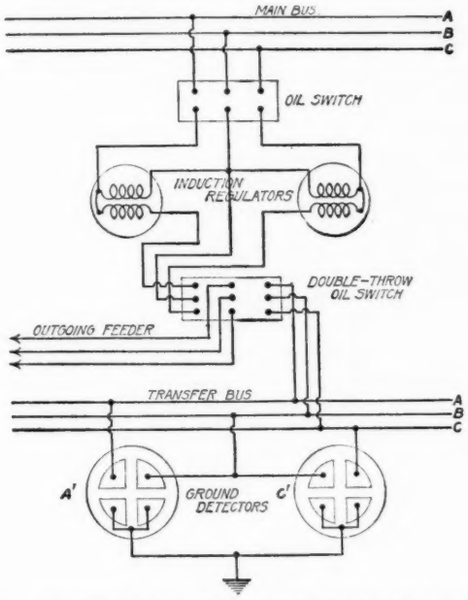


FIG. 5. CONNECTIONS FOR ELECTROSTATIC GROUND DETECTORS TO THREE-PHASE CIRCUIT

the electrostatic meters being more sensitive in this respect than the lamps. This condition is particularly true of distribution feeders having induction regulators where the ground indicators are connected beyond the regulators, such as in the arrangement shown in Fig. 5. If the regulators become so adjusted that there is considerable difference in voltage between phases on the circuit feeding the transfer bus, the detectors will indicate a ground. The unbalanced voltage at the terminals of a Scott-connected transformer will cause a ground indication. In one substation having 4,000-kva. 13,000-volt three-phase to 2,400-volt two-phase transformer banks, when thrown on the secondary bus carrying the ground lamps these transformers always caused a ground indication on the lamps until some load was connected to the bus.

Before any ground indication is accepted as final, the voltages of the phases of the circuit should be checked to make sure that they are alike. There have been occasions when troublemen wasted time in searching for grounds that never existed, but were indicated on the detectors due to an unbalanced voltage. In layouts such as that in Fig. 5 it is better to locate the detectors on one of the main buses rather than on the transfer bus, for this reason.

One great disadvantage of the ground transformer not shared by the electrostatic detector is the tendency of the transformer to burn out under a ground. As soon as the ground has been located, the ground transformer must be taken out of the circuit. Few accidental grounds make a solid connection; usually, they are of an oscillating or arcing character; and the constant hammering on the transformer of the charging current overheats the iron and windings.

To definitely locate a ground, each piece of apparatus in turn will have to be disconnected from the bus until the ground indication clears when the faulty apparatus is isolated. A ground on the secondary circuit of a transformer will not show up on its primary circuit. Where a station has duplicate busses, apparatus to be tested for ground may be transferred to a separate bus, fed by another alternator or transformer, and isolated from all other apparatus. When the ground instruments show clear after the faulty apparatus has been disconnected from the bus, the defective equipment alone may be carried on the bus having the ground meters, as a further check that that apparatus is at fault.

On the Road with the Refrigerating Troubleman

By J. C. MORAN

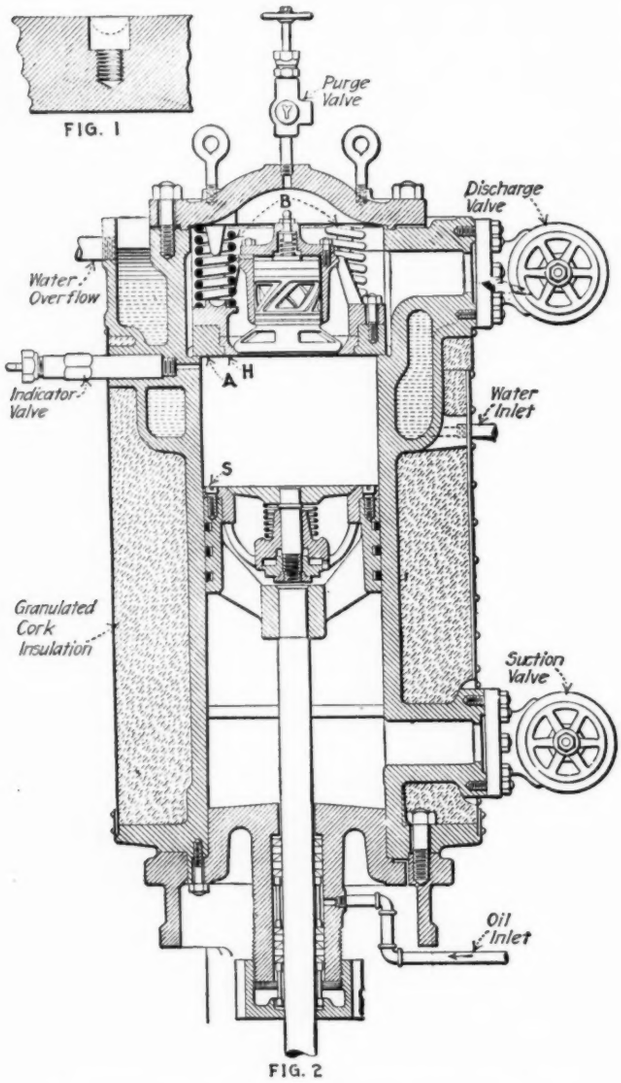
He is sent to estimate how much capacity in new machines was needed to enable the overloaded, neglected plant to carry its load. The owner threatens to fire the whole crew when told by the troubleman that with needed repairs the present machines will easily carry the load. Another stormy scene occurs when he gets the estimate for this work. But next season he is happy for he handles more produce with 60 tons of coal now than with 80 tons before; and he has a new engineer whom he pays far more than he did in the old troublesome days.

THE refrigerating plant of a packing house in the South was getting too small for the load. It was almost impossible to keep the temperatures low enough even at average load, and when a heavy load came it was necessary to buy ice for the high-temperature coolers. Things had been going from bad to worse for several years. The owner was of the kind that would never spend a cent in the power plant until something stopped. As a consequence two good chief engineers had given up in despair, and one of the men who had grown up in the plant held the position. He was another of those fellows, like the owner, who believed in cutting expenses by putting off repairs and in addition driving the men as hard as possible. So the plant, crew and the chief, were wrecks.

It was up to me to go over the plant and give the owner an estimate of what capacity of new machines would be needed to carry the load. After going over the figures several times, I called in another man who knew his business to check my figures. He agreed that the present plant should be plenty large enough with capacity to spare. When we made the report to the owner, he raved and wanted to fire the whole crew and hire a new one. He was advised that all he needed was a new chief, a thorough overhauling of the entire refrigerating plant and then to do as the chief told

him in the matter of buying supplies and expenses for repairs. He threatened to throw me out of the office, but finally cooled off and asked me to recommend a chief and then make an estimate on the needed repairs. He had another outburst when I gave him the estimate for the work, but he O. K.'d, and in a few days I also found him a new chief at a salary nearly twice what he had been paying.

In making the estimate, I had figured doing nearly everything that could be done to the plant, feeling sure that some of this work would not be necessary. When



SECTION OF AMMONIA COMPRESSOR CYLINDER, SHOWING SEAT "A" WHICH CRACKED

we came to go through the plant, I found that everything that I had figured on would be necessary, if not more.

There were four machines in the place—two 100-ton of the vertical single-acting type and two 75-ton of the horizontal double-acting type. We started on the latter first.

Three of the four piston rings on the first machine were broken, and the last one did not hold itself against the cylinder wall. The second machine had two rings broken, and the tension of the two remaining rings was useless. After we had the rods disconnected from the crosshead, we could push the pistons forward against the crank head with practically no effort by placing the foot against it and giving it a boost. The gas had been leaking back around the pistons as fast as it had been pumped out, or in other words possibly half of the gas that should have been delivered leaked back around the pistons, and the only way they could keep the machine cold was to carry a lot of liquid over with the suction gas. Otherwise it would run so hot that it smoked.

We had the cylinders bored, provided new pistons and new rings that made a snug and tight fit in the cylinder. The piston rods were about $\frac{3}{16}$ in. smaller at the center than at the ends with heavy score marks on them. With the old rods it had been impossible to keep the stuffing-box from leaking, and as all the rest were in the same condition they must have wasted several hundred pounds of ammonia a month.

In adjusting the crosshead shoes, they had followed the general practice in steam-engine work of adjusting the bottom shoe for taking up the wear, the wear on the steam-engine shoe generally being on the bottom unless the engine is running under. On a compressor the action is just the reverse and the wear is on the top. As a consequence, with the piston wearing on the bottom in the cylinder and dropping this end of the rod and then adjusting the bottom shoe for wear on the other end, the rod was nearly a quarter of an inch higher at the crosshead end of the rod than at the piston end. It was traveling through the stuffing-box at an angle all the time.

The valves were in as bad condition. One of the discharge valves was so badly worn that it had worked down through the seat far enough to touch the piston at every stroke, while the piston prevented it tightly seating. We put in four new valves and cages out of the total of eight and reground the valves and seats of the rest. We also put in lighter springs on all of the discharge valves, as someone had ordered new springs that were about three times as strong as required. The proper spring was determined by taking indicator diagrams with different spring tensions and then adopting the spring that would operate the valve quietly, show the smallest possible rise above the discharge pressure at the time it opened and at the same time close promptly, as indicated by the re-expansion line on the suction stroke.

After covering a number of other details, such as lining up the cranks and mainshaft, rebabbitting the top crosshead shoes, crosshead and crankpin brasses, babbitting the oil lanterns in the stuffing-boxes and clearing out the ammonia oil lines to the stuffing-boxes, we were ready to put them in service.

The work was done during the early part of the winter or we would never have been able to take two machines out of service at once. There was also a slack period, but just about the time we had finished the two machines, an exceptionally heavy run came along and the owner came to the engine room three or four times a day to see if he could bluff or coax us to hurry the work along.

We had the machines ready about a day before the rush came and had them running smoothly. We cut them both in on the system in the middle of the afternoon when the coolers were being filled with a rush, and that night we had about three times the load to carry that we had had for some time past. The "Old

Man" was on the job about six o'clock the next morning and every cooler was ahead of schedule and a number of them were down to 33 deg., which had never been known before.

Before cutting in the newly overhauled machines, we put in 1,200 lb. of ammonia, which had something to do with bringing the coolers down because the system was literally starved for ammonia.

The old man by this time came to the conclusion that the new chief and myself probably knew more about the business than he had given us credit for, and we got anything we wanted. We next tackled the vertical machines which had been in operation only three years, but were in a bad condition. The pistons and rings were good, though we peened out the rings slightly so as to bring more pressure against the cylin der wall. The cylinders were not worn sufficiently to need reboring, and this was largely due to the slight wear on the vertical cylinder, there being no wear from the weight of the piston, only from the pressure of the piston rings.

Vertical Machines in Need of Repairs

The rods were bad, being both scored and worn more in the center than at the ends. Both rods were sent to the shop to be turned up, while we fitted a junk ring in the bottom of the stuffing-box to make a snug fit on the rod after turning to prevent the packing working out between the space between the smaller rod and the neck of the stuffing-box. The oil lantern also had to be rebabbitted to fit the reduced size of the rod.

The crosshead adjustment on these machines was not so bad as on the other two, but one of them was out nearly one-eighth inch. Trouble had been experienced with the stuffing-boxes. When we removed the false head of the first machine, we found a sorry state of affairs. From somewhere a small piece of babbitt had got clamped between the false-head seat and the head, preventing it seating properly, and as a consequence the gas had been continually leaking back through on the suction stroke on this one cylinder of this machine. The head and cylinder on the other side were in good order. All that was necessary on this machine was to grind in the suction and discharge valves and the false heads.

The other machine was worse than the first. A piece had been broken out of the false-head seat on one of the cylinders and left a passage almost large enough to hold a lead pencil directly across the seat. We remedied this by drilling a hole slightly wider than the widest part of the break and about an inch deep, and then tapping the bottom part of this hole, which was made slightly smaller than the first one-third of an inch at the top. We then screwed into this hole a plug (see Fig. 1) that was a snug fit in the top section and filed it down to a smooth finish with the rest of the seat.

And this was not all. Two of the screws that held the suction-valve cage in the piston, as indicated by *S*, Fig. 2, had backed out about half an inch. Instead of opening up the machine and looking into it to see what was the matter, the crew had merely backed the piston rod farther into the crosshead until the noise made by the pounding of the screws against the false head has stopped. In this way they had operated this cylinder with about half an inch clearance and of course at greatly reduced capacity.

Referring to Fig. 2, *B* indicates the springs which hold the false head against the seat, *A* and *H* show the valve seat of the discharge valve. It was from this seat *A* that the piece was broken out as already mentioned. The screws were so badly battered that they were useless, and we had to tap the holes over again and insert larger screws. A piece was also cracked out of the discharge valve seat *H*, Fig. 2, and we had to remove the seat and get a new one after which we ground in the valves on all cylinders of both machines.

After this was done, we adjusted the clearance on all the pistons so that they were from $\frac{1}{64}$ in. to $\frac{1}{32}$ in. from the head.

After we had the machines together again, we ran them for a couple of days intermittently, during which one of the machines had a serious pound that we were unable to locate. We looked everywhere, keyed up all the bearings, pins and crosshead shoes without results. The pound was there as soon as the machine was run at normal speed, while at lower speeds it would sometimes pound and at other times would not. Some of the boys thought it was the piston hitting, and we changed the clearance adjustment, but without results. The pound seemed to come just after the crank had passed the top center and was a kind of a dull thump. After thinking the matter over, I decided to try one more "wrinkle." We removed the cylinder head and placed washers, $\frac{1}{4}$ in. thick on the false head springs *B*, Fig. 2, which would put more pressure on the false head, the washers being put on the top of the spring. When we started again the pound was gone.

Old Ammonia Withdrawn

During the time we went over the compressor end of the machines, we also rebored two of the steam cylinders of the compressors, inserted a few new piston rings, refaced the steam valves and seats, lined up the bearings, etc., reset the valves and covered every detail in the best possible way. After this had been covered, we blew out the expansion coils with steam and air, these coils being heavily loaded with oil. The condensers got the same treatment, and at the same time we purged a lot of air and foul gas from the system, which had boosted the condenser pressure about 30 lb. above normal. In cleaning the coils and condensers, we took first one condenser and cleaned it and then cleaned a certain part of the expansion coils, probably one brine tank or a set of direct-expansion coils in some of the storage rooms. We then started one machine on the clean system and continued in this manner, charging new ammonia into each part of the system cleaned as we went along. In this manner we finally collected all the old impure ammonia in one condenser, from which it was drawn and sent to the manufacturer for purification.

About three months later, during the latter part of the spring, I dropped into the plant for a visit. The owner was the most pleasant man one could wish to meet. He drew out some records of the previous season and also some of the most recent. In these were shown the output of the packing plant during both periods and also the coal consumption. With considerably greater output at this time the coal consumption was only about 65 tons per day as against an average of 80 for the preceding year. Best of all, everyone was satisfied. Whenever the new chief asks for anything within reason, he gets it.

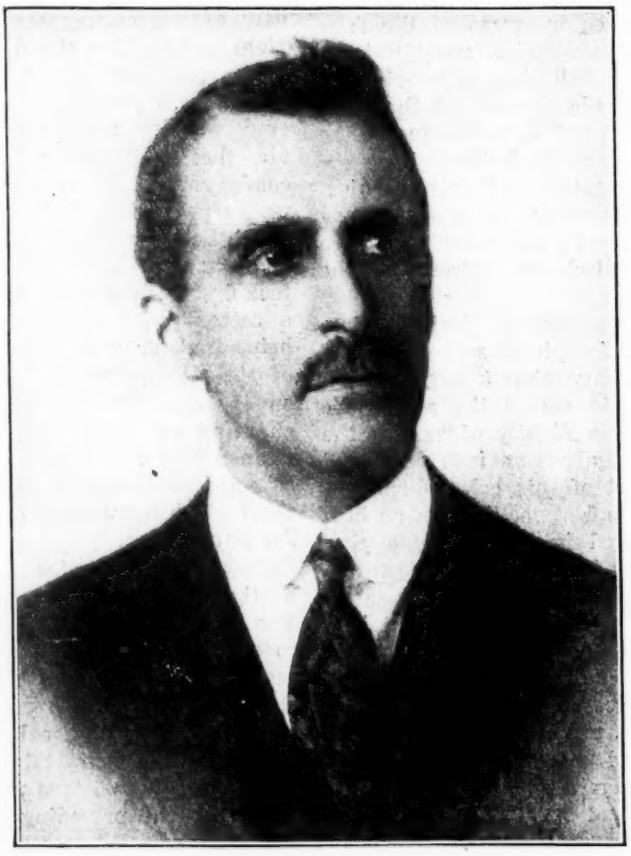
An Expert in Economical Power Production—Foster McKenzie, of Cleveland, Ohio

> *"The chief engineer of a power plant is primarily engaged to operate the station so as to produce power at the lowest possible cost, consistent with good service and with keeping the equipment in first class repair. One of his most essential requirements is the ability to follow out the intent of the designer of the mechanical element and to fit the human element to work in synchronism with it. In other words he must be a diplomat with some engineering ability."*—FOSTER MCKENZIE.

FROM the time of James Watt, there has been a very close connection between the steam power industry and men of Scottish birth and ancestry. This hardy race which has turned out so many first class engineers and technical men, has a worthy son in Mr. Foster McKenzie, until recently in charge of the Cleveland Municipal Light Plant. Mr. McKenzie was born in Scotland, April 17, 1881, and was educated at the Hamilton Academy in that country. Our first records of his activities in America show him as master mechanic and chief engineer at the Newark (N. J.) plant of the Sherwin-Williams Co., the largest paint and varnish manufacturers in the world. In his nine years at this plant he made some very good records in the cost of power production.

Mr. McKenzie's real opportunity came with his employment by the Municipal Light Department of Cleveland. The Cleveland plant, which represents a $3,000,000 investment, was designed by F. W. Ballard, and built with a view to obtaining the very best possible efficiency in power production. With this end in view the plant was equipped with carefully selected apparatus and types of measuring instruments that might help in obtaining economical operation. Boilers and stokers were equipped with automatic regulating devices, steam flow meters, draught gages, etc. All boiler feed water was to be measured, and its temperature, before entering the economizer and the boilers, shown by recording thermometers. Coal was to be bought on the heat unit basis and tests made daily. In fact the designs called for recording the operations of the plant to the most minute detail.

The designers realized that the men who operated the plant would be a more important factor than the apparatus or instruments installed. Putting then, the same thought and care into the selection of the chief of operation as into the selection of apparatus, they chose Mr. McKenzie. He was called to the plant about a year before it was completed and spent that time in supervising the installation of the equipment. That he has justified the confidence of those who selected him, is shown by the fact that the consumption of coal has been brought down to a little less than two pounds per kilowatt-hour.



FOSTER McKENZIE

Mr. McKenzie has given us some interesting figures and information about this plant. With coal at $2.10 per ton, bought on a 13,000 B.t.u. basis (with a bonus for higher, and a penalty for lower heat values) the cost in 1916 was 0.3 cent per kilowatt-hour at the busbars. This cost covers fuel, maintenance, labor (including switchboard operators), and sundries, but does not include any taxes or depreciation charges. At about this time the average CO_2 in the flue gas was 16 per cent, and an average thermal efficiency of 13.5 per cent was obtained.

At this plant the scheme of using condensate from the main surface condenser as cooling water in the condenser for the "house alternator" was originated. It had been found that, at the vacuum carried, the temperature of the feed water was so low as to cause the economizer tubes to sweat. Using the feed as cooling water in the smaller condenser raised the temperature to a point where no further trouble was experienced. This idea was later successfully adopted at the new Conners Creek station of the Detroit Edison Co.

Like many of our prominent professional men, Mr. McKenzie gave liberally of his time to Government service during the war. He served as a member of the Committee of Fuel Conservation for the Cleveland district throughout the period of hostilities. He was also a member of the United States Public Service Reserve.

He is now a member of the firm of the McKenzie Engineering Co., also chief engineer and a director of the Ohio Pipe Bending Co., and chief engineer and member of the Plastic Metallic Packing Co. In connection with the McKenzie Engineering Co. his work has been largely devoted to problems of burning fuel oil under steam boilers.

Harrisburg Dual-Clearance Engine

It is common knowledge that two diametrical opinions are held as to the relative merit of auxiliary exhaust valves on uniflow engines, the difference of opinion effecting engines operating non-condensing

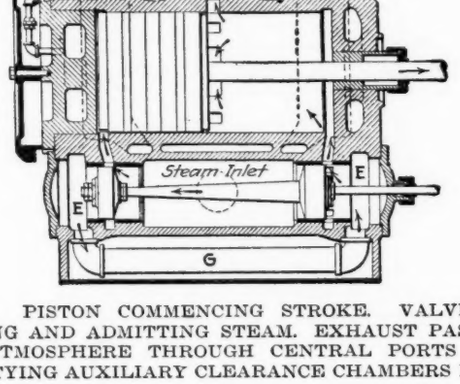


FIG. 1. PISTON COMMENCING STROKE. VALVE JUST OPENING AND ADMITTING STEAM. EXHAUST PASSING TO ATMOSPHERE THROUGH CENTRAL PORTS AND EMPTYING AUXILIARY CLEARANCE CHAMBERS E G E

and the value of the valves as a safeguard against accident due to excessive compression.

Auxiliary exhaust valves when used with uniflow engines are for the purpose of delaying the commencement of compression by relieving the cylinder of more of the expanded steam than can escape through the central exhaust port, and so reduces the amount of final clearance that must be provided.

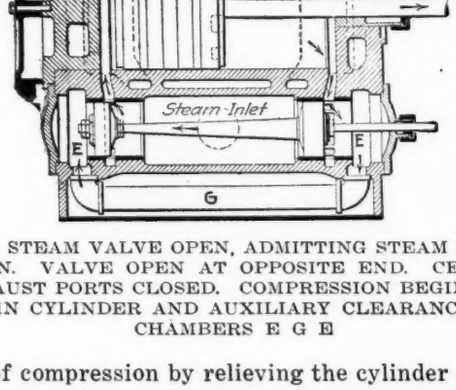


FIG. 2. STEAM VALVE OPEN, ADMITTING STEAM BEHIND PISTON. VALVE OPEN AT OPPOSITE END. CENTRAL EXHAUST PORTS CLOSED. COMPRESSION BEGINNING IN CYLINDER AND AUXILIARY CLEARANCE CHAMBERS E G E

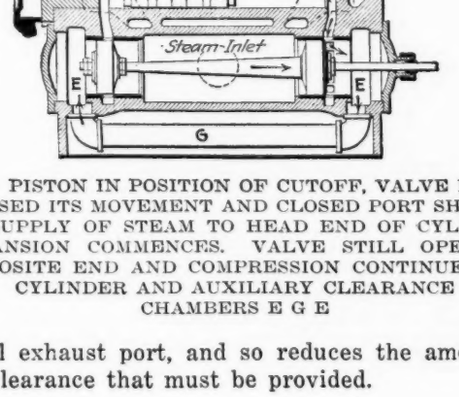


FIG. 3. PISTON IN POSITION OF CUTOFF, VALVE HAVING REVERSED ITS MOVEMENT AND CLOSED PORT SHUTTING OFF SUPPLY OF STEAM TO HEAD END OF CYLINDER. EXPANSION COMMENCES. VALVE STILL OPEN AT OPPOSITE END AND COMPRESSION CONTINUES IN CYLINDER AND AUXILIARY CLEARANCE CHAMBERS E G E

The latest development in engines of the uniflow type has been brought out by the Harrisburg Foundry & Machine Works, Harrisburg, Penn., in what they term the dual-clearance single-cylinder uniflow engine. This engine is designed with two clearances and the accompanying illustrations show how the steam is expanded from a small clearance and, by means of the single-balanced piston valve, is allowed to compress first into a large chamber and finally, as the piston nears the end of the stroke, into a smaller clearance.

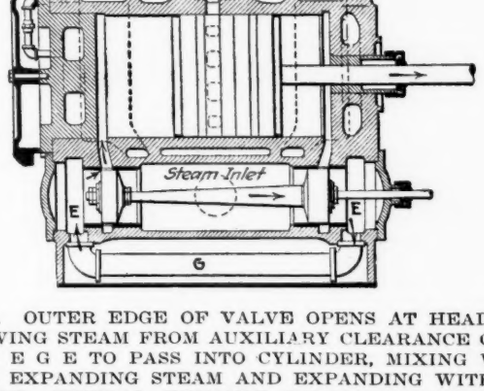


FIG. 4. OUTER EDGE OF VALVE OPENS AT HEAD END ALLOWING STEAM FROM AUXILIARY CLEARANCE CHAMBERS E G E TO PASS INTO CYLINDER, MIXING WITH THE EXPANDING STEAM AND EXPANDING WITH IT UNTIL CENTRAL EXHAUST PORTS ARE OPEN TO ATMOSPHERE. OPPOSITE END OF VALVE HAS CLOSED PORT, AND COMPRESSION OCCURS IN CYLINDER AND CYLINDER CLEARANCE ONLY

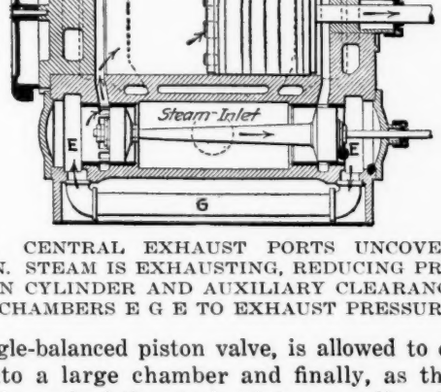


FIG. 5. CENTRAL EXHAUST PORTS UNCOVERED BY PISTON. STEAM IS EXHAUSTING, REDUCING PRESSURE IN CYLINDER AND AUXILIARY CLEARANCE CHAMBERS E G E TO EXHAUST PRESSURE

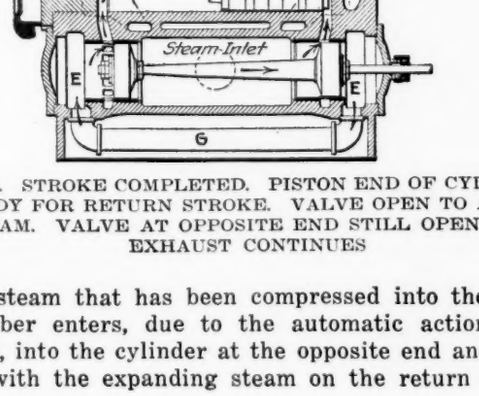


FIG. 6. STROKE COMPLETED. PISTON END OF CYLINDER READY FOR RETURN STROKE. VALVE OPEN TO ADMIT STEAM. VALVE AT OPPOSITE END STILL OPEN AND EXHAUST CONTINUES

The steam that has been compressed into the large chamber enters, due to the automatic action of a valve, into the cylinder at the opposite end and, mixing with the expanding steam on the return stroke,

expands with it and passes out through the central ports to the exhaust line. An examination of the accompanying illustrations and the captions fully explains the action of the valve and its control of the steam to and from the auxiliary clearance chambers.

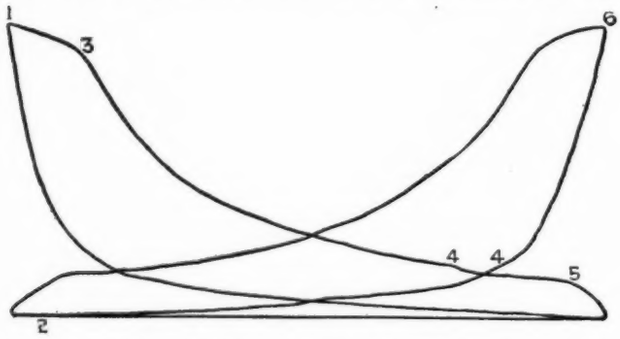


FIG. 7. DIAGRAM FROM DUAL-CLEARANCE ENGINE. FIGURES INDICATE POSITION OF PISTON AND VALVE FOR THE EVENTS OF THE CYCLE

Peculiar Flywheel Accident

By E. E. Clock*

The following is an account of a flywheel accident which occurred at the plant of the Goodyear Rubber Shoe Co., of the United States Rubber interests, at Naugatuck, Conn., on Jan. 19 last:

The wheel was on a tandem compound condensing Hewes & Phillips engine of 800 hp. built in 1905, and had been used previously during the life of a former engine of the same make and had been dismantled and reassembled about 15 years ago upon the installation of the present engine. The joints were made up with O links which had been cut at the time the wheel had been dismantled and had been rewelded, some of the welds giving way and showing poor work. The weakness of these links no doubt was the largest factor in the sad results, as the wheel evidently went to pieces at a speed much lower than the computed bursting speed, for investigation showed that the wheel went to pieces some seconds after the throttle had been closed tightly.

There is no doubt, however, that the links had begun to give way previous to the closing of the throttle and that the reaction caused by the drag of the pistons through the closing of the throttle produced some flexure of the arms that had a disastrous effect on the weakened links.

The sequence of events during and just previous to the accident was as follows: The engine was connected to its load by an electrically operated clutch with switches located along the line of heavy shafting which drove the rolls. There were two engines just alike side by side, both connected to a common condenser located in the basement. At five minutes to one on the fatal day the chief engineer went to the basement as usual to start the condenser, the two other men standing ready to start their respective engines when the vacuum gages should show that all was ready. Both started up in regular form, but No. 2 engine ran overspeed because someone had tripped the electric clutch, leaving the engine with no friction load. This caused the governor to go to the extreme top, and being equipped with the Hewes & Phillips trip device, which dropped the governor cutoff mechanism to the bottom or no steam position, the engineer without closing his throttle, got up on the engine and lifted up this cutoff mechanism one or more times, probably expecting every second that the whistle would blow and the load come on. In the meantime noting the increase in speed one of the other men closed the throttle and the man on the engine jumped down and gave the throttle an extra pull. All then ran out into the yard through a door in line with the wheel; a second later the crash came, and when the dust cleared up the man who had been on the engine was found in the yard so badly injured that he lived but a few hours.

The rim of the wheel was 15 in. square and weighed 40,000 lb. made up in eight sections. Two sections still held together by the links passed up through four floors of heavy mill construction including heavy yellow-pine timbers and then fell back through the fourth floor in another spot, landing on the third floor and in its flight badly injuring one man and damaging considerable material and machinery. Another section of the wheel passed through the brick wall in front of the building and landed on the street, miraculously missing the many people constantly passing there.

The lesson to be learned from this accident is to know that your men will do the right thing in cases of unusual emergency, and to anticipate those emergencies and be prepared for them in advance. Men who can be trusted to do the right thing in a routine way should from time to time be drilled in the matter of all possible emergencies. The next best cover for such failures in the matter of engines probably is the installation and the daily testing of a good reliable mechanical speed limit and one that can not be put out of action in the interest of keeping the engine from shutting down at any cost.

*Safety engineer.

Hydro-Electric Power in France

Hydro-electric power development has been given much attention in France and is being rapidly made available for use. If fully developed, this power will total 9,300,000 hp. according to the "Index to French Production." In the report of the American Industrial Commission to France (1916) the total on low-water flow was estimated at 4,600,000 hp.

Until 1914 the total developed hydro-electric power was approximately 800,000 hp., and when the plants recently completed are in full operation and those under construction have been finished, the total will be double the 1914 figures. Shortage of coal during the war stimulated water-power development, and a number of the railroads and industries throughout the country, which have suffered through lack of fuel, are considering the development of hydro-electric power as the only solution of the problem.

The River Rhone is a fine example of the possibilities of water-power development in France. No less than 750,000 hp. can be made available by this river it is estimated. This is equal to a saving of 5,000,000 tons of coal per annum. Operations for the ultilization of this power have already started, and as a number of large manufacturing cities are within transmission distance of the river, it is believed that a ready market for the power will be found. The cost of this work will be in the neighborhood of $125,000,000, according to figures taken from the data gathered by the Direction Generale des Services Français aux Etats Unis, New York City.

EDITORIALS

Plant Successfully Operated Under Difficulties

THE leading article in this issue describes the power equipment of the Chile Exploration Co. at Tocopilla. Although in general the equipment does not differ radically from that found in a modern American plant, the conditions under which it had to be constructed and operated make it intensely interesting. Whatever may be the problems involved in the design and construction of power plants in the United States and Canada, earthquakes do not enter into them. In the plant under consideration overcoming or at least minimizing the effects of earthquakes, was one of the important problems to be solved. Where there is no fresh water other than that distilled from the sea, conservation of feed water is paramount, for every pound of steam wasted means one pound of feed water that must be replaced by the burning of expensive fuel. When a plant is built along the seaboard, it is generally afforded the protection of a good harbor. At Tocopilla a rocky coast line, rising sharply out of the sea and exposed to the waves, had to be contended with, and complicated the circulating-water and fuel-handling problems. When the nearest reliable fuel supply is approximately four thousand miles away, this in itself is something to be considered seriously before a plant of fifty thousand kilowatts capacity is attempted, let alone transmitting the power across ninety miles of desert. The design and construction of a plant to operate under such conditions make it of more than passing interest.

The favorable results obtained in this plant with distilled feed water make this method of obtaining a supply of boiler feed, where the natural source of supply contains a large percentage of impurities, worthy of more attention than it has received in this country. Especially in this true since the loss of heat is very small if the evaporators are properly insulated. Two factors have stood out to a high degree in the operation of this plant: namely, absence of scale in the boilers and corrosion of the steel-tube economizers. Where boilers are being forced as they are in our modern power plants, the absence of scale is vital in preventing the burning of tubes.

In the operation of the electrical end two features in particular warrant comment—one the method of cooling the transformers, and the other the washing of the insulators on about eight miles of the transmission line nearest the coast. Not infrequently serious trouble has been experienced with the cooling coils of water-cooled transformers becoming clogged with scale. At Tocopilla the only source of cooling water available is the sea, consequently it is not difficult to imagine the trouble that would be experienced if the water was circulated through the cooling coils. By placing the cooling coils in a tank of water and pumping the oil through them, it has been possible to eliminate troubles from this source. Although this practice has been adopted to a limited extent here, there are apparently many conditions where it could be used to good advantage. The duplicating of the first eight or ten miles of the transmission line so that the salt deposits can be washed off the insulators of one line while the other is in service evidently gives a constructive suggestion toward solving some of the transmission troubles experienced in this country at railway crossings and places where the insulators collect deposits that cause them to flash over.

Apart from the solution of the power problems there stands the engineering achievement that has made possible the tapping of great mineral resources in a section of a country where a burning sun and drifting sands hold sway. In this we find another brilliant example of what the application of power can do for the betterment of mankind.

Safety in Storing Bituminous Coal

"ANOTHER objection to the storage of bituminous coal is its tendency to spontaneous combustion. It cannot be denied that this danger is a real one with improperly stored coal. It has been proved, however, that bituminous coal can be stored safely and that it will suffer little or no depreciation if reasonable care be used."

The preceding paragrapn is quoted from a recent *Power* editorial on methods of stabilizing the bituminous-coal industry. The question as to what is "improperly stored coal" is answered in a paper on "How Bituminous Coal Can Be Stored Safely," by Prof. H. H. Stoek, an abstract of which appears in this issue. Space limitations prevent the printing of this paper in full, but the abstract is well worth study.

The causes of spontaneous combustion seem very simple. If air can get at the coal, oxidation will start. Oxidation causes heat and if the ventilation is not sufficient to carry off this heat, the temperature of the coal will rise and the oxidation will become more and more rapid. The remedy or preventive seems equally simple. Either give the coal plenty of air or cut off the supply entirely. The difficulty lies in the fact that the ordinary coal pile is well designed to admit just enough air to cause trouble. However, as Professor Stoek pointed out, properly piled coal overcomes this tendency to a very great extent.

A study of some coal-storage arrangements shows that a campaign of education is badly needed. After presenting his paper, Professor Stoek showed a number of lantern slides from photographs of coal-storage piles that had fired. In many cases the side or back of the boiler setting formed one side of the coal bin. Coal was shown piled on top of steam pipes and around chimneys. With this sort of storage it is not to be wondered that fires result. Where coal is stored in larger quantities, the pictures showed that almost every rule suggested in the paper had been violated.

In short, bituminous coal is often stored with no more care than would be given to storing sand, and the result is usually disastrous. If intelligence and care are used, the chances of trouble are practically eliminated. To Professor Stoek's advice, "Before you store coal, be sure you know how to do it," we would add, "You can learn how to store coal, and it will pay you to learn and to apply your knowledge."

Scientific Study of Boiler Design

THE paper by F. W. Dean and Henry Kreisinger, on page 348 *et seq.* of *Power* for March second, shows the possibilities of a thorough scientific study of boiler and furnace design. The building of a thousand wooden ships by the Emergency Fleet Corporation, each requiring two boilers of twenty-five hundred square feet of heating surface each, made it worth while to test the design adopted in the most thorough manner for possible improvements in efficiency as well as for dependability.

Never, probably, has a boiler been the subject of so searching a surveillance of its performance or of so many experimental modifications. Apparatus was provided not only to determine, with an unusual degree of accuracy, the boiler and furnace efficiency, but with a rare degree of refinement the temperature and composition of the gases were determined at numerous points in the furnace, passes and uptake, the water circulation was observed in direction and activity, the temperatures of the casing, inside and out, were measured, and by changing the baffles, modifying the manner of admitting air over the fire, etc., the efficiency of the boiler was increased from about sixty to about seventy-two and a half per cent.

Would not an equally systematic and intelligent investigation result in a corresponding improvement in some of our commercial installations?

Instruments in the Steam Plant

IT IS nice to have a lot of books. It gives one a scholarly, cultured air and smacks of wisdom and erudition. But smack and air are all they will amount to for one who simply sits and looks at his well-filled shelves and smokes his pipe.

If one could get into one's head all that there is in a book by paying for it, we would all be Solomons. To absorb it requires time, interest, study, thought and application—not to learn a book by heart, but to get a commanding sense of what is in it and be able to use it to advantage.

It is nice to have a lot of instruments around a plant. It looks scientific and impressive and smacks of technical training and efficiency; but they will never pay a dividend on their cost if they are not kept in condition as instruments of precision, if they are not continually or frequently used, and if their indications and records are not studied understandingly and the deductions therefrom intelligently applied. There is no use of providing an engineer with an indicator if he does not know how to get a correct diagram with it and, what is of more importance still, if he does not know the full significance of the diagram and, with it as a guide, keep his engines, pumps and compressors in adjustment and maintain a fair record of his output. Coal-weighing and water-measuring apparatus is of no value to a man who does not understand how to use their indications to determine how well his plant is doing and why it is not doing better. Boiler efficiency cannot be improved by putting in a CO_2 recorder if one does not keep it in operation and know something more of what it tells than that a high percentage of CO_2 is, in general, most desirable.

The only instrument of which most steam plants can boast is a pressure gage, ordinarily within ten per cent of right. The engineer does not know how much water his boiler evaporates per pound of coal, how much steam his engine takes per horsepower or how much power it develops. He does not know the temperature of the feed water, the intensity of the draft or how hot the gases are leaving the boiler. He has no means of telling how completely the fuel is burned or how much more air than is necessary to burn it is heated to the uptake temperature and discharged to the stack. He ought to be provided with the instruments and apparatus necessary to determine these and other things, but it is useless to do this unless he takes an intelligent interest in their use and translates the stories that they tell into a record of the greatest efficiency attainable under the conditions.

Publicity for Engineering Societies

NEVER before has engineering figured so prominently in the solution of vast problems to the nation as has been brought about by the conditions of reconstruction. As a consequence the public is receptive as to activities of the engineering profession, yet they are kept, to a certain extent, in the dark as to engineering accomplishments that are going on every day, and plans for the future. The daily press makes little attempt to collect information from the engineering societies, while on the other hand the societies have no facilities for proper dissemination of such news.

A publicity bureau as a medium for communication between the societies and the technical and daily press is suggested. Such publicity work could function through an established technical publicity bureau, or the societies could jointly establish one of their own in charge of a man with a broad and comprehensive knowledge of the requirements of such work. The first plan would seem to possess certain advantages at the start by making use of existing connections and might perhaps prove less expensive, although in the long run the second plan might prove the better. In any event the need of such publicity is urgent and it is hoped that early action may be taken by the societies on this matter.

The effectiveness of competent inspection in the prevention of boiler accidents is shown in the Annual Report of the Chief Inspector of Locomotive Boilers, in which it appears that the number of accidents caused by the failure of the locomotive boiler and its appurtenances shows a decrease of 60.2 per cent for the year ending June 30, 1919, as compared with that ending June 30, 1912, the first year in which the law was in operation. The number of persons killed was decreased 50.5 per cent and the number injured 58.9 per cent.

CORRESPONDENCE

Height of Return-Tubular Boiler Setting Above Grates

In the Feb. 10 issue of *Power* my young engineers have observed your answer relating to the height of settings for a 72-in. return-tubular boiler. I believe that if this was brought to your more careful attention you would like to make a statement that the boilers should be set four to five feet above the grates, which we find modern practice rather than 30 to 36 inches.

We have put in several installations with boilers set at these heights, and I must say that the results are very gratifying. JOHN A. STEVENS.

Lowell, Mass.

[The higher a return-tubular boiler is set above the grates the less chilling effect in hindering the perfection of combustion; but less advantage is obtained from the receipt of heat by direct radiation from the fire and there is more heat lost by infiltration of air and radiation from the greater extent of the side walls. The question under discussion is: Under average conditions of draft, fuel and firing, what height of boiler setting of a given size obtains combustion that results in the highest average efficiency? It would be interesting to know under what operating conditions it was found that a height of 36, 48 or 60 in. for a 72-in. boiler gave the best boiler efficiency under actual test.—Editor.]

Characteristics of Chain-Grate Stokers

In the Jan. 27 issue of *Power*, H. F. Gauss. on page 144, describes some of the characteristics of a chain-grate stoker. He attributes the frequent failure of the coal to ignite to the large size of the coal permitting a considerable volume of air to pass through, thus retarding or preventing ignition. An instance is cited in which steam was admitted under the ignition arch and the successful result was assigned to the steam pressure preventing the ingress of excess air.

It would appear that steam at the necessary pressure and in the quantity required to produce the result as described, would be sufficient to prevent ignition altogether; this, because the steam must be superheated to the ignition temperature of the coal before ignition could occur.

An installation as described by Mr. Gauss, in which steam was blown under the ignition arch, was brought to my notice about a year ago. It occurred to me that the design of the ignition arch was faulty in that the surface was horizontal, forming a pocket into which the reflected heat rays from the incandescent fuel could not enter. The effect of the steam injection was to induce a current of hot gases from the furnace which ignited the coal.

Experiments on arches that I have made have resulted in effects varying from failure of ignition in the case of flat arches to the destruction of the coal gate, in the case of arches with too much rise.

Kansas City, Mo. C. O. SANDERSTROM.

Boiler Blowoff Pipes

Recently the elbow on the blowoff pipe of a 40-hp. boiler failed under 100 lb. pressure. Although the boiler is rated at 40 hp., it was working at around 70 hp. Luckily, I had previously closed the steel fire-door separating the boiler room from the factory.

As the combustion chamber had not been cleaned out for some time, there was considerable soot all over the place, because when the explosion was heard someone opened the door leading to the boiler room, but he did not linger long. The soot also plugged the tubes so tight that it required five men to punch them out.

This pipe between the boiler and the side wall was unprotected, and that is what caused the trouble, as the hot gasses had burned the pipes and the elbow, although it had been in place but about a year. The boiler is blown down every morning, and upon examination no trace of scale could be found. When a new pipe was put in, it was protected by a brick baffle. The owners had been told by the inspectors to put some kind of protection around that pipe, but had neglected to do so. R. G. SUMMERS.

Syracuse, N. Y.

Straightening Shafts By Heat

The method of straightening a shaft by the application of heat to the high side, as described by E. E. Clock on page 377 of *Power* for Sept. 2, is entirely practicable. We straightened shafts nineteen years ago at Erie, by pouring hot babbitt against the side that needed to be shortened.

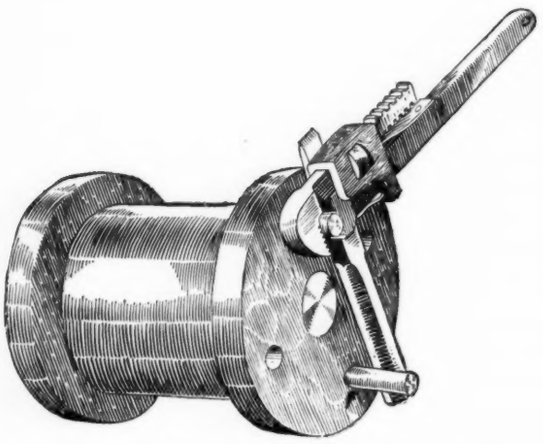
We have also used this method to straighten milling-machine platens which became bent up in the middle of their length, the same as planer platens, because of the peening effect of handling work on their top surface.

The process is the reverse of peening and, like it, is but temporary in its effect. It should be used only to counteract some similar strain. J. A. STRONG.

Erie, Penn.

Removing a Tight Pin from a Casting

An easy way of removing a tight fitting pin from a casting is by the use of an ordinary stillson or pipe wrench and a cold chisel or wedge. The chisel is placed flat against the casting, and the wrench is applied to the pin in such a way that when the pin is turned,



ONE WAY OF REMOVING A PIN FROM A CASTING

the chisel will act as a wedge or lever and tend to draw the pin out. The method as shown in the sketch practically explains itself. W. W. PARKER.

Firestone, Col.

Burning Fuel Oil

Before coming to my present power plant, I had charge of a large coal-burning plant equipped with stokers that were supposed to be the last word in mechanical firing. It was no uncommon thing to ask and receive 150 per cent rating of the boilers, and this without any extra strain apparently on the firing machinery, but there was always the possibility that a fire would clinker and cause trouble and there was also the possibility that a stoker might fail. In fact, they did fail at times. And then again there was always a chance that the crusher elevator scraper or some other part of the coal-handling machinery might get out of order. Therefore a stock of working parts for this machinery was carried.

For a coal-burning plant it was modern in all ways and the amount of help required per thousand horsepower was small, but there is no comparison between the coal-burning and oil-burning plant. Imagine several boilers under forced and induced draft, each boiler furnace containing around three tons of coal at a bright cherry, not white, heat. The noon whistle blows and then the several safety valves blow.

Of course the water tender lowers the water at 11:30 and has all the available space posible for storing new water at 11:55, but with the fires necessary to keep the wheels turning and the kettles boiling it is almost impossible to hold the safety valves shut. Thus good coal in large amounts, figuratively speaking, goes through the safety valves. It is almost impossible to prevent this waste.

In the oil-burning plant no thought of steam going through the safety valves is present. At 11:58 the oil is shut off, at 12 m. the oil is put on two, three or four boilers—just enough to hold steam for the noon hour—and no excitement prevails whatever.

With oil, no thoughts are given to ash or clinker; no thoughts are given to fires in the coal pocket. No thoughts are given to disgruntled firemen. All thoughts are centered on the temperature of the oil in the main storage and auxiliary tanks. Temperature is the watchword in the oil-burning plant. A difference of five degrees in the temperature of the oil will cause smoke.

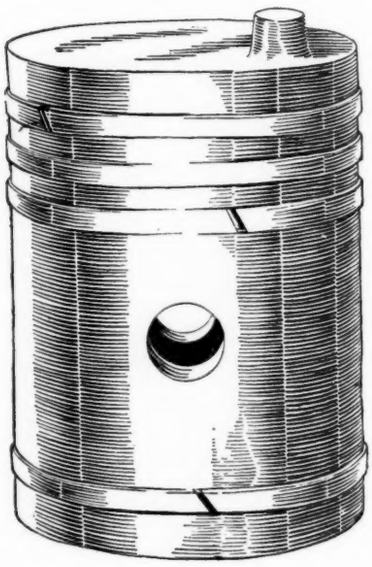
This is the first lesson the boiler-room engineer learns. He next learns that even a trifling raise of pressure in the oil line causes smoke unless a like increase is given to the steam line feeding the burners. Burners will score, owing to the action of the oil and steam passing through them, and a scored or grooved burner will cause smoke. Apparently, the flames from two burners touching causes smoke. How do we operate without smoke? We don't operate without smoke at times, and sometimes the heavens are blackened most outrageously by smoke from our stacks, but not for long.

By a careful watch of conditions, a micrometer adjustment of valves and the ever-present thought of temperatures and oil pressures, the plant is able to do 150 per cent rating under adverse conditions.

New York City. C. W. PETERS.

Why the Piston Would Not Come Out

Although solid-head internal combustion-engine cylinders are not built to any extent at present, many of them are in use, and this brings to mind the projection illustrated by the sketch, the purpose of which



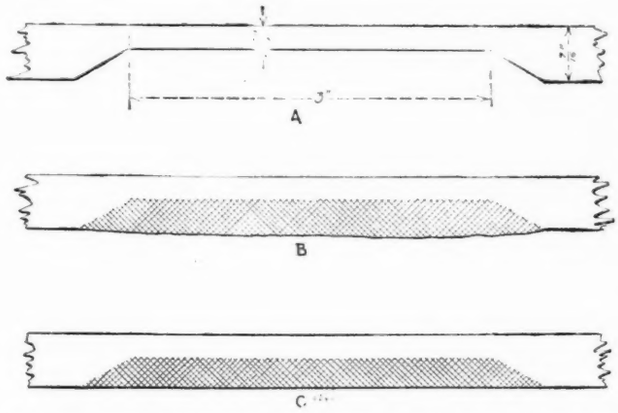
SHOWING THE PROJECTION THAT WAS SAWED OFF

should be obvious. In one instance the owner sawed this projection off, evidently under the impression that it was useless. When the piston was replaced in the cylinder, it was pushed in too far and the upper ring, extending past the cylinder top counterbore, expanded and locked the piston securely into the upper end of the cylinder. H. H. PARKER.

Oakland, Cal.

Repairing a Boiler-Plate Lamination

Recently, a lamination was discovered on the bottom of a return-tubular boiler, directly over the furnace. A patch was suggested, but as it was not considered advisable to have one applied in such a location, it was suggested that the lamination be cut out and the cavity filled with metal by means of the electric-welding process. The lamination appeared to be only about 1 x 1½ in. and about $\frac{3}{16}$ in. deep, but by the time we had it



LAMINATION REMOVED AND METAL WELDED IN PLACE

cleaned out, it proved to be 3 in. in diameter and ¼ in. deep, leaving $\frac{3}{16}$ in. good plate as at *A*. The cavity was filled with metal *B* above the surrounding plate and ground down flush so that there is now no evidence of a fault as at *C*. If the boiler does not convert itself into a projectile, we may assume that the operation is a success, but if it turns up missing some time, we will know what did it.

Since this job was completed I understand that the boiler-insurance companies have sanctioned such practice, but have prohibited another that I have seen done; namely, re-ending boiler tubes. Our Department of Public Works, Boilers' Branch, permits re-ending by the autogenous process, but when my suggestion regarding filling the cavity of the lamination was put up to them, they passed it on to the insurance company, and the inspector who sanctioned it, I have since learned, did not know that such a method was practiced. I think that the practice should be all right. R. McLAREN.

Toronto, Ont., Canada.

Wet Floor Caused Ground on Motor Circuit

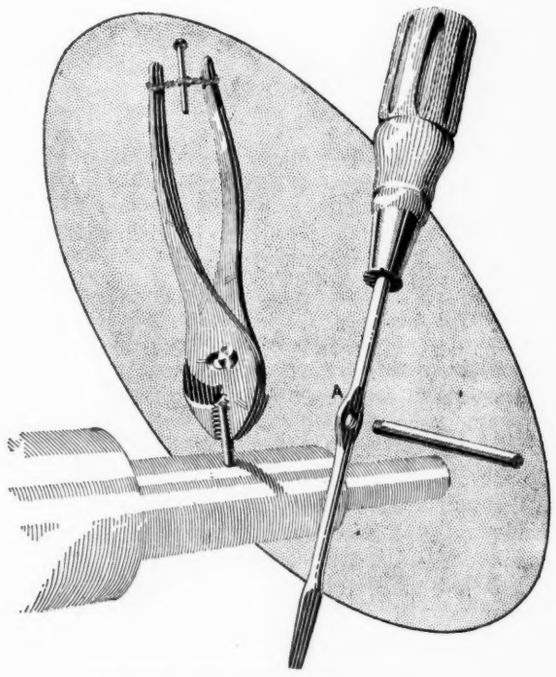
In a large industrial plant several employees received rather unpleasant electrical shocks when attempting to turn on the water at a sink. It was known that several motors were grounded to the water mains, of which the supply pipe to the sink was a branch, but this offered no solution of the puzzle. The sink was not grounded, as it was suspended by brackets to a wooden wall, and the waste pipe only extended through the wall, the discharge falling into the river below. However, even if the sink had been grounded, the water mains themselves would have furnished a much better path to earth, in case of a grounded motor, than would have been possible through the body of a man at the sink.

The floor around the sink was always more or less water-soaked, and an investigation here finally disclosed the source of the trouble. At a distance of a few feet, and well within the wet area, the conductors of a 440-volt motor circuit were carried down the wall on cleats and passed through the floor into the room below. These wires had each been originally protected at the floor line by porcelain-tube bushings, but in repairing a section of the floor the carpenters had allowed the tubes to slide down, and then cut notches in the floor boards to admit the wires only. One of these notches had been made such a close fit that when the floor became water-soaked, the wood swelled very tight around the wire. Of course its insulation in turn became soaked and useless. The moistened area of the floor extended but a few feet, and a path to ground was completed only when someone stood on the wet floor and touched the water pipe. HAROLD B. PHILLIPS.

Appleton, Wis.

Making a Pair of Pliers and Screwdriver More Useful

Quite often, when using a pair of pliers in gripping a small dowel pin to pull it out, it is impossible to get strong enough grip with the strength of one's hand. In such cases the kink shown to the left in the figure will be found handy—that of using a turn or so of heavy string or some small wire and twisting it tight with a



PLIERS AND SCREWDRIVER KINKS

nail. This trick can be used to convert the pliers into a temporary hand vise.

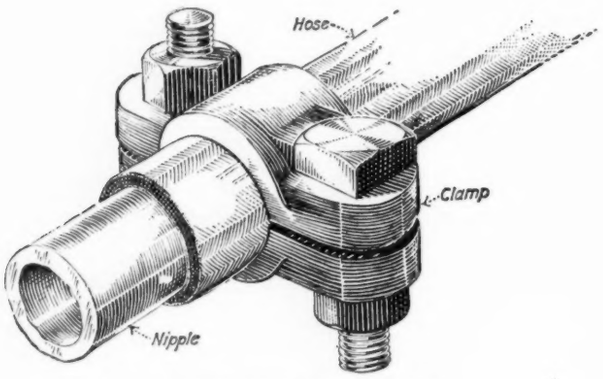
On the right of the illustration is shown a simple way to convert an ordinary round-shank screwdriver into a powerful type of lever driver. The section *A* is simply flattened and then drilled and tapped to take a threaded handle, which is a small bolt with its head cut off. The handle is removed when it is desired to use the screwdriver without it. CHARLES H. WILLEY.

Concord, N. H.

Clamp for High-Pressure Hose

We use a method of repairing a leaky hose that is employed in the mines, as follows:

The hose is cut at the leak and for a ¾-in. hose a ½-in. nipple 6 in. long is inserted halfway in the hose. A ¾-in. nipple 7 in. long is used for a 1-in. hose, such as is illustrated herewith. The hose is clamped to the nipple by the type of clamp shown. Sometimes a marlin spike is used in the hose to enlarge it a little.



HOSE COUPLING CLAMP

Under high pressure and where the hose is subject to hard usage, several strands of wire can be run on each side from one coupling to the other and twisted as desired.

COLIN F. MCGIBBSON.

Butte, Mont.

Location of Secondary Relays Affect Voltage Regulation

A company operating a number of induction feeder regulators mounted the contact-making or primary relay upon the switchboard and the secondary or reversing relay upon the regulator. However, this secondary relay was not mounted as recommended by the manufacturer, but, instead, was supported by iron strips to the top of the regulator case. This arrangement was inexpensive and appeared quite satisfactory. However, in one of the installations where a new type of regulator was installed, difficulty developed in that the regulator was not functioning properly. Sometimes the voltage would rise as the load came on, then would remain high although the load decreased, and vice versa. This did not always happen, and sometimes the regulator would operate for days and even weeks without giving any trouble.

At first routine troubles were looked for; the contacts of the contact-making voltmeter were cleaned and adjusted for correct voltage range; the contacts of the reversing switch were overhauled and adjusted; the regulator brakes were tested, the drums oiled and the tension of the brake shoes reduced. These adjustments had no apparent effect, and intermittent short-circuits were suspected, but no trouble of this nature was found.

What was found was that at certain times of high voltage and therefore increased flux density in the regulator iron, and when a certain frequency of the system occurred, possibly due to current changes, the regulator was caused to give rise to severe vibration. This was in turn passed on to the secondary relay, which also vibrated under the influence of normal operating current passing through it. In this manner the natural periodicity of vibration of the relay had superimposed upon it the vibration of another periodicity. The effect of this vibration was that while the contacts of the secondary relay appeared to be making good mechanical contact, the circuit to the regulator motor was not permanently closed. Instead, the circuit was rapidly opened and closed without apparent movement of the relay contacts so far as the naked eye could see. Moreover, the two poles of the relay might or might not close simultaneously. Since a three-phase induction motor cannot start up single-phase, the result was that either the motor could not get started in time before the circuit was interrupted or else it could not start at all. In either case the result was the same—poor voltage regulation.

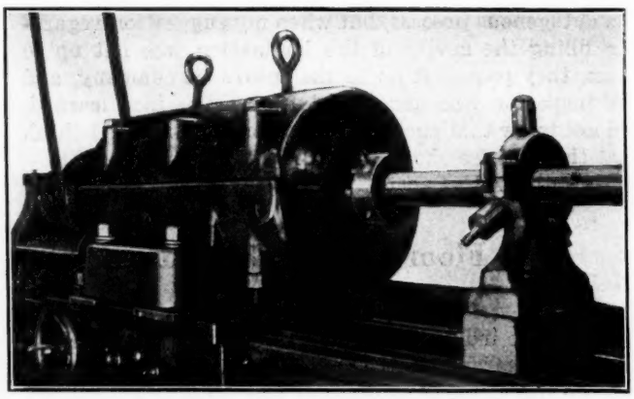
The remedy was simple. The secondary relays were left in their original position. But instead of being bolted down tight to the iron strip supports, so that vibration of the induction regulator cases was transmitted to the relays, spring washers were placed underneath the case of each relay, at the four corners. The bolts were then inserted and the fastening nuts screwed down so as to prevent the bolts from falling out. The relays were allowed free movement up and down, always resting on the spring washers and yet unable to fall off the supporting strips. This solved the problem and incidentally eliminated much burning of contact-making contacts.

B. W. SMITH.

Cicero, Ill.

Method of Boring a Large Bearing on a Small Lathe

The illustration shows how a bearing was bored out on a small lathe that was not strong enough to hold the weight of the bearing and had to be blocked up to prevent breaking the bed. The tool post was removed,



BEARING READY FOR BORING OUT ON SMALL LATHE

and the carriage was made to fit the bearing by the use of channel irons. The boring bar was a piece of scrap shafting with a set collar to hold the tool. The bed of the lathe was supported by means of iron stands wedged tightly between the lower side of the bed and the floor. This way of boring large bearings proved very satisfactory and has been used on a number of different bearings.

W. R. CATON.

Buffalo, N. Y.

INQUIRIES OF GENERAL INTEREST

Triple Riveting of Lap Joints—Why are lap joints of high-pressure steam drums frequently made with three or more rows of rivets? F. C.

A triple-riveted lap joint may be designed of higher efficiency than a double-riveted lap joint, and the greater width over the rows of rivets renders it easier to bring the plates into line, with the result that there is less bending than in the single- or double-riveted lap joint.

Turbine a One-Speed Machine—Can a steam turbine be constructed that will develop a normal rated power at different speeds? A. L. M.

The turbine is a one-speed machine. For good economy the speed of the rotating buckets must bear a definite relation to the velocity of the steam as determined by the design. Otherwise there will be wasteful impact of the steam against the vanes and the speed of the turbine cannot be changed from that of best economy without serious loss of efficiency.

Transfer of Heat Requires Difference of Temperatures—If at sea level fifteen pounds of steam at atmospheric pressure is to let into an open barrel containing 150 pounds of water at the boiling point, what temperature would the water attain? C. E. G.

The temperature of dry saturated steam at atmospheric pressure is 212 deg. F., and the boiling point of water under atmospheric pressure is at the same temperature. There could be no transfer of heat because the temperature would be the same and the temperature of the water would remain unchanged.

Belt Thickness Influences Speed Ratio of Pulleys — Should not a 36-in. pulley drive a 12-in. pulley at three times the speed of the former? R. F.

If the pulleys operate as friction pulleys running in contact without slip, the 12-in. pulley will be driven at three times the speed of the 36-in. pulley. But if separated and the driving is done by a belt without slippage, the small pulley will be driven at something less than three times the speed of the large one on account of the thickness of the belt. In making calculations of speeds without slippage, an amount equal to the thickness of the belt should be added to the diameter of each pulley.

Obtaining Compression of Exhaust on Corliss Engine—How can compression of exhaust be increased on a Corliss engine? E. D. C.

With a double eccentric Corliss engine, advance the exhaust eccentric. As opening and closing of each exhaust valve occurs when the piston is at the same part of its stroke, earlier closure for obtaining more compression will also cause earlier release after cutoff. With a single eccentric for operating all valves, advancing the eccentric hastens all valve events and causes the steam valves to open earlier. If the resulting lead is too much, the time of opening the steam valves must be delayed by adding lap to those valves. This is done by adjusting the length of the steam valve rods so the opening edges of the steam valves will lap over their ports when the wrist plate is in its central position, giving $\frac{1}{32}$ to $\frac{1}{16}$ in. opening for lead when the piston is at the beginning of its stroke.

Induction-Motor Winding Bracing—Why are insulated rings placed over the ends of induction motor coils where they extend beyond the stator core and why in some cases are they placed on both ends and in others on one end only? K. A. R.

Frequently, where the coil throw is long or if the coils are not mechanically rigid, the ends are liable to be distorted when a heavy current flows through them. To prevent this, insulated rings are placed around the outside of the winding and the coil ends laced to these rings with heavy cord. This practice has been found to increase the life of the coils, since it tends to prevent any vibration of the coil ends that would otherwise occur. Where the throw of the coils is short, the rings are only put on the end of the winding opposite to the one where the cross-connections are made, the cross-connection giving the necessary support to the coil ends on the end of the stator winding where the connections are made.

Variation of Boiler Rating for Difference of Pressure—What would be the difference in rating the capacity of a boiler operated at 150 or 125 lb. pressure? V. A.

Boiler evaporative capacity is based on the rate of absorption of heat transferred to the water in the boiler, a boiler horsepower consisting of a rate that is equivalent to the transfer of heat required to evaporate 34.5 lb. of water from and at 212 deg. F., or 33,479 B.t.u. per hour. The lower the temperature of the water of a boiler the greater its difference of temperature from the temperature of the fire and heated gases and the more rapid the rate of heat transfer. Operation at different pressures also might be attended by difference in rate of transfer due to difference in the character of circulation of a boiler; but the differences in the rates of transfer of heat when generating steam at 150 or 125 lb. gage pressure would be negligible, and for all practical purposes the rating would be the same.

Twenty-five-Cycle Transformers on 60 Cycles—Will 25-cycle transformers 6,600-volt primary 220-volt secondary work on 60 cycles 6,600-volt primary 220-volt secondary? E. R. G.

Twenty-five cycle transformers can be operated on 60 cycles, but 60-cycle equipment cannot be operated on 25 cycles. For the same output the 25-cycle equipment will be considerably larger than the 60-cycle, consequently where 25-cycle transformers are operated on a 60-cycle circuit, the unit would be considerably larger than a 60-cycle transformer of the same capacity. When the 25-cycle transformers are used on 60 cycles, the exciting current and the flux density in the coil will be only about four-tenths what it is for the 25-cycle circuit. When 60-cycle equipment is operated on a 25-cycle circuit, the exciting current and flux density will theoretically be 2.4 times that of the 60-cycle circuit. However, due to the saturation of the iron core, the exciting current may be many times this value, and will cause the transformer to overheat even when operating without any load.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

How Bituminous Coal Can Be Stored Safely*

By H. H. STOEK
Professor of Mining Engineering, University of Illinois

THE following statement has been prepared from material published by the Engineering Experiment Station, University of Illinois, in Circular 6 and Bulletin 116. These publications give the details of an investigation by the station that has been in progress for about three years. During this time the practice of storing coal has been studied under a great variety of conditions and for stocks varying from a few tons up to hundreds of thousands of tons. The data were obtained through questionnaires, conferences, personal inspection of storage piles and a detailed study of over one hundred fires in coal piles said to be due to spontaneous combustion. The conclusions here given apply only to bituminous coal and have no reference to anthracite or lignite.

Small Quantities Give Little Trouble in Storage

For such amounts of coal as are required by the ordinary householder, it can be stated positively that, (1) there is little or no likelihood of spontaneous combustion, as heating can be detected readily and the coal moved, and (2) there is no loss in heating value that would be appreciable in the conditions under which such coal is burned. Where several hundred tons of coal are stored, as in large buildings and schoolhouses, extra precautions should be taken in the storing and then in watching for evidences of heating.

For the storage of coal in quantities, say above 500 tons, the experience and practice of those who have stored coal successfully under similar conditions should be given careful consideration. Before it is time to begin the actual storage, a suitable place should be prepared and a definite policy outlined. Storage instructions should be prepared in detail and carried out to the letter.

It is probable that all varieties of bituminous coal have been stored without spontaneous combustion resulting, and it is equally true that all varities of coal have fired when stored, excepting possibly anthracite. This does not mean that all coals store equally well, as there is a wide difference in this respect between various varieties. There are not sufficient data available at this time to classify coals as to their liability to spontaneous combustion, and it is doubtful if this can be done, because liability to firing seems to depend more upon the size of the coal, its freedom from dust, the way in which it is piled and to a less extent on the amount of pyrite present.

Coal of Uniform Size Is Easiest To Store

Clean, screened coal of a uniform size should be chosen if it is available. The larger and more uniform the lumps the better. Sized coal should not be stored upon a foundation of fine coal. The coal should be handled in such a way as to prevent breakage as much as possible. It should not be dropped upon a pile from a height, but the bucket or other receptacle lowered to the pile before being dumped. In every case of a fire in so-called lump coal, that I have investigated, it was found that the coal had been dropped through a considerable height, so that coal on the pile contained a large amount of dust.

In storing mine run coal, it should be piled in uniform layers, in small low piles, and segregation of the sizes prevented. The piles should be as low as the space will permit, carefully watched and provision made to quickly move the coal if heating occurs. The spontaneous combustion of coal is due largely to the oxidation of the fine material and the confining of the resulting heat; consequently, its liability is greatly reduced and in many cases eliminated if dust and fine coal can be kept out of the piles, if the coal is of such size and so piled that there is sufficient air current to carry off the heat, or else if the coal is so closely packed that the air cannot come in contact with the fine coal to cause oxidation.

If fine coal or slack is to be stored, it should be carefully watched to detect evidences of heating. If practicable the slack pile should be rolled so as to compact it as much as possible, thus excluding the air, so as to give as nearly as possible storage-under-water conditions.

Although experimentation has shown that the sulphur contained in coal in the form of pyrite is not the chief cause of spontaneous combustion, the oxidation of the sulphur in the coal not only produces heat but also assists in breaking up the lumps and thus increases the amount of fine coal in the pile.

It seems to make little difference in the liability to spontaneous combustion whether the coal is stored under cover or in the open, but under cover there is less segregation and weathering. If possible a place should be chosen that is dry and well drained, or if not drained naturally, drains should be provided around the piles, not underneath it. A drain beneath the pile may produce an air current up through the pile and thus assist spontaneous combustion. The coal should not be dumped on ground covered with ashes or refuse of any kind, because in addition to furnishing flues for the admission of air, such refuse often contains material such as waste, rags, papers, and so forth that will start spontaneous combustion. Furthermore, this refuse may be gathered up with the coal when it is reclaimed and the value of the fuel be depreciated.

Coal should not be stored around hot pipes, against a boiler, or hot walls, around a chimney or in any place where it is subjected to outside heat. Coal should not be stored above flues that will permit a current of air to enter the pile. Hot air, such as that from a sewer, is particularly to be avoided. Care should be taken to arrange the storage pile so that any part of it can be moved promptly if necessary.

Danger from Stratification

Stratification, or segregation of the fine and lump coal into layers, should be avoided, since an open stratum of coarse lumps provides a passage for air to reach the fine coal, and the layer of fine coal does not permit the heated air to pass out rapidly enough to keep down the temperature. Coal should not be dumped at one point on the top of a conical pile, since the fine coal stays in the center at the top, and the lump coal rolls to the bottom. Many coal fires start near the top of the pile where the fine coal has prevented the escape of the heated gases. In placing coal in a cellar or bin the same precautions should be observed, for many fires are known to have started in the fine coal just below the window through which the coal was shoveled in.

The depth and area of storage piles will be determined largely by the storing space available and the mechanical appliances for storing and reclaiming coal. Other conditions being equal, the deeper the pile and the greater the area the greater the difficulty in inspecting and moving it quickly, if necessary; hence a number of small piles are better than one large pile.

The exact effect of moisture in connection with spontaneous combustion is not definitely known. The repeated wetting and drying of coal, however, seems to increase this tendency, probably owing to the breaking up of the coal which results. It is not wise to put wet coal into a pile, or to store dry coal on top of wet coal or on a damp base. After a rain or snow storm the coal piles should be carefully inspected and watched.

Water is an effective agent for quenching fire in coal piles only if it can be applied in sufficient quantities to extinquish the fire and cool the mass. Most coals coke on heating, and a protective coating is thus formed about the hot spot which prevents the water from reaching it. To be sure that the water reaches the burning coal it is usually necessary to dig into the pile and turn it over.

*Abstract of a paper presented at the February meeting of the American Society of Mining and Metallurgical Engineers.

Coal in storage should be inspected regularly, and if the temperature reaches 140 deg. F., the pile should be carefully watched. A rapid rise from this point to 150 or 160 deg. indicates that the coal should be moved as promptly as possible. If the temperature rises slowly, the pile should be carefully watched, but it is not necessary to start moving it at as low a temperature as when it rises rapidly, for the temperature may recede and the danger be past. Coal that has once heated should, if possible, be used at once and not returned to the pile, for experience shows that such coal is peculiarly liable to heat again.

Timbers extending to the outside of the pile may permit the entrance of air to the interior. It is important, therefore, to avoid piling coal around the end of trestles or in such places where timbers, coarse cinders, etc., offer a passage for the air.

The effect of ventilating coal piles is a disputed point, but the weight of evidence in the United States seems to be against the practice. This may possibly be due to the fact that ventilation has been inadequately provided. Imperfect ventilation, such as generally attempted in this country, is certainly disadvantageous. Reports from Canada favor ventilation by pipes placed closed together in the coal pile, although this arrangement may interfere with reclaiming devices.

A plan for coal storage must consider all the conditions, and not only a portion of them. For instance, clean lump coal of a certain kind may be stored with perfect safety in high piles, while the same coal, run-of-mine or unscreened, may not store at all or at least only in small piles. Lack of attention to details in storage or failure to systematically inspect storage piles and to be ready for any emergency that may occur, may result in losses from fires. Before you store coal, make sure that you know how to do it properly.

The Engineer to Participate in Public Affairs

At the midwinter convention of the American Institute of Electrical Engineers President Calvert Townley, in an address, directed the attention of the engineer to a greater participation in public affairs. The speaker referred to the endorsement of the report of the Institute's Development Committee by the members as a step of far-reaching importance, particularly the part dealing with the desirability of greater participation by the engineer in public affairs and that which recommends that the Institute co-operate with other engineering bodies to bring this about. It was stated that the machinery for co-operation between the various engineering societies was well under way, and that two other engineering societies had already agreed to participate in the movement. After pointing to how extremely gratifying it was, to those who did sponsor the Engineering Council, that the membership at large had now very definitely expressed the view that the movement should be continued and should be expanded far beyond anything previously undertaken, Mr. Townley said:

"It would be premature, not to say hazardous, to say now that if and when delegates from a large number of societies come together they will organize, and that sponsors will support a federation such as has been proposed by the joint conference committee, but at least the national society will have done their duty, and if the plan should carry it will place in the hands of a democratic body of engineers, chosen from engineering organizations of every kind all over the United States, a large measure of authority and responsibility to speak for the engineering profession and to take united action on matters of common concern. It is because of the far-reaching character of this prospective step that I was chosen to speak to you about tonight. I regard it as one of the most important of the organization matters which are today before the engineers of the country."

In outlining some of the things that a national engineering organization could properly do Mr. Townley recalled some of the work performed by the Engineering Council and said that its first activities were to help the Government during the war to find engineers suitable for the many different tasks for which they were sorely needed. Another activity was to co-operate with the Government, through the medium of a large committee, in passing upon the merits of the enormous number of new and untried devices and processes and inventions submitted during the war. Since the armistice the Council has co-ordinated the employment bureaus maintained over a period of years by some of the Founder Societies; conducted and is still conducting an exhaustive examination into the classification and compensation of engineers in Government service; at work collecting and compiling all available data in an endeavor to prepare a uniform license law for engineers to be recommended to all states where such legislation is being considered; co-operated with the United States Chamber of Commerce by presenting certain fundamental data on the question of water power which aided materially in passing the water-power legislation in both the House and Senate; testified before Federal authority on many different subjects, always endeavoring to confine itself to fundamental engineering facts and to keep away from political and other questions. In explaining what the new organization would be the speaker said:

"One of the fundamental features of the plan prepared by your Development Committee and which also appeared in that adopted by the joint conferees, is that the new national organization shall be composed of delegates from existing engineering bodies. It will not be a new society composed of individual members. Such a plan was given exhaustive consideration by the conferees and in the end decisively rejected. The primary objection to the plan adopted is that the work of the new organization is to be quite different from that in which most of the old organizations have been engaged. Instead of dealing in the main directly with technical or interorganization matters, it will deal more largely with public affairs, and as the existing societies are not organized for this purpose and in fact have not done it, but have in some instances shown opposition to the idea, they should not be relied upon to back it now, but on the contrary an entirely new body should be created, one that is not hampered or shackled in any way. The answer to this argument is that while the existing societies were not organized for the kind of work now contemplated, several local affiliations of them have been functioning around many of the sorts of work proposed for a number of years and doing it well and that the Engineering Council has already proved its efficiency and only needed a larger appropriation and a more representative membership to be afforded by the new plan to occupy a much wider field."

Should Confine Activities to Engineering Matters

In closing his address President Townley said: "The only other comment which I feel should be made is a word of caution and is born of my experience while serving the Institute on Engineering Council. The body has been beset on all sides to advocate or to oppose legislation, and while it has not hesitated to do so when the questions involved were of a nature where the advice of engineers would be of particular value, it has steadfastly declined to become involved otherwise. Bearing this fact in mind my word of caution is against any policy which will cheapen the engines.

Our collective advice is valuable on subjects with which we are qualified by experience and training to do, and so long as we confine ourselves to such subjects and present a united front our influence can and will be considerable. But the minute we digress and begin to deal with matters outside the purview of engineering and subjects closely allied thereto we sacrifice our preferred position and have no more claim to be heard than any other body of educated citizens of similar number. We also would then almost make the very serious mistake of misrepresenting our membership, because, while engineers can be safely counted upon to agree upon fundamental facts, they are of all shades of political belief and have as many different views as any one else regarding other questions. My word of caution therefore is really a plea to you to give this side of the subject your due thought and to make your views known at all proper times and places."

Hoover's Food Drafts—A New System for Sending Food to Individuals in Europe

In order to help relieve the critical food situation in eastern and central Europe, the American Relief Administration has adopted a plan whereby any individual in America may supply a friend or relative in Europe with a food package or anyone desirous of helping to give to the unfortunate may do so on payment at any one of several thousand banks in America. In a letter to the bankers of America, Herbert Hoover, Chairman of the Relief Administration, outlines the plan as follows:

Throughout the whole of central and eastern Europe the food supply of the people falls into two classes: First, the ration issued by the government; second, illicit circulation of food available to those who have a sufficient amount of money. The government ration is necessarily meager and nowhere sufficient to properly maintain life, and must be supplemented. Under these circumstances the scramble for such supplementary margin has placed the price of the illicit food supplies entirely beyond the reach of the great bulk of the population. To illustrate: A single ham outside the ration system sells for as high as one hundred and fifty dollars.

There are three to four million families in the United States with family affiliations in eastern and central Europe. Many of them are desirous of giving direct personal assistance to these relatives and friends. Some are endeavoring to perform this service by preparing or purchasing packages of food for overseas shipment. In some cases the packing and extra freight involved add 100 per cent to the cost. We are proposing to solve this difficulty by establishing warehouses to carry stocks of staple foodstuffs in European cities where distress is particularly acute. We propose to sell, in America, orders upon these warehouses in the form of "Food Drafts," which can be transmitted to friends or relatives in Europe. We propose to charge the buyer of the "Food Draft" the factory cost of the food plus a reasonable margin to cover cost of transportation and insurance. Profits, if any accure, will be turned over to the European Children's Fund.

The object of this plan is to add to the total stock of available food supplies in central and eastern European countries. Under an arrangement set up with the governments of these countries, this food will be allowed to revolve outside the rationing system, with the hope that enough food will be injected to reduce the pressure on the narrow marginal supplies. The officials of these new governments are endeavoring to impress upon the American people that it is useless to remit money to a family in central or eastern Europe with the hope of improving its food situation. The sum total of food now available in central Europe is insufficient to keep the population alive, and under these circumstances money thus becomes that much paper so far as nutrition is concerned. A hungry man wants food, not money, and under the arrangement outlined, we can meet his need.

It is hoped that the facts concerning this "Food Draft" system will be given as much publicity as possible, especially among the foreign-born who have relatives and friends in the suffering countries. It is also hoped that many Americans will help the general situation by buying drafts made out to "General Relief" and sending them to the Relief Administration, whose representatives will distribute the food where it is most needed.

Diesel Engine-Users Association

There was a large attendance at the February meeting of the Diesel Engine Users Association, London, and a considerable amount of interest was evidenced in the discussion that followed the reading of Geoffrey Porter's paper on "Wear of Diesel Engines." In dealing with the important question of "liner wear" he referred to this as being chiefly influenced by the percentage of ash content in the fuel oil and its variable nature according to the class of fuel used, the quality and quantity of lubricant, the method of lubrication, the fit of pistons and piston rings in the liner, the side thrust due to the connecting-rod and the quality of the material used. The author also pointed to the deleterious effect of excessive cylinder lubrication, which resulted in the formation of carbon deposits on the piston. Particulars were given as to the proper clearances in the case of cooled and uncooled pistons of various sizes, and the important subject of "growth" of cast iron was again referred to.

G. W. F. Horner, in discussing the paper, referred to the subject of "growth" in cylinder liners and instanced the particulars of actual cases in which he had taken accurate measurements.

W. A. Tookey thought there was very little doubt that the wear of piston liners and piston rings was correlative. In the case of horizontal engines it had been found that the maximum wear occurred at the joint of the back piston ring.

A. N. Rye had not noticed that the use of tar-oil fuel had been detrimental to cylinder liners, but it had a marked effect on valves and other portions of the engine gear. He referred to the effect of granite dust in the air in the case of some engines situated near a granite quarry. The abrasive effect of the granite dust introduced into the power house when the wind was in certain quarters had caused a considerable amount of trouble in the cylinders until air filters had been introduced. Mr. Rye expressed approval of the barreling of cylinder liners as a means of reducing piston-seizure trouble.

Particulars concerning the association can be obtained on application to the honorary secretary, Percy Still, M.I.E.E., 19, Cadogan Gardens, London, S.W.3.

N. E. L. A. Convention

The National Electric Light Association has completed a tentative program for the forty-third convention, to be held at Pasadena, Cal., May 18-22. General sessions will be held during the mornings and special sessions in the afternoons. Governor William D. Stephens of California will deliver the address of welcome at the opening session. Response will be made on behalf of the association by President Ballard. Following this, M. H. Aylesworth, executive manager, will outline the reorganization work of the association to date.

A report of the Committee on Water Power Development will be read by Franklin T. Griffith, of the Portland Light and Power Co., who will be followed by A. E. Silver, of the Electric Bond and Share Co., chairman of the Inductive Interference Committee, who will read a report on "Inductive Interference." "Electrification of Steam Railroads" will be the subject dealt with in the report of a committee on that subject, presented by Frank M. Kerr, of the Mountain Power Co., of Butte, Mont. Other reports and speakers will be: "Electrical Resources of the Nation," by M. S. Sloane, of the Brooklyn Edison Co.; George B. Foster, of the Commonwealth Edison Co., of Chicago, chairman of the Electric Vehicle Section of the association, will deliver an address on "Development, Manufacture and Marketing of the Electrical Vehicle"; Zena W. Carter, secretary of the Material Handling Machine Manufacturers' Association of New York, will read a paper entitled "Electric Machinery for All Handling"; and the Association Committee on Public Information, of which John F. Gilchrist, of the Commonwealth Edison Co., of Chicago, is president, will give figures and facts showing the value of proper publicity of association activities.

During the afternoon session on Friday, May 21, a report of the Committee on Federal and Municipal Transportation will be read by James H. McGraw, chairman, of the McGraw-Hill Company, Inc. Mr. McGraw will be followed by F. M. Feiker, chairman of the Committee on Transportation Engineering, also of the McGraw-Hill company. Mr. Feiker will read the report of the committee. On May 19 during the first afternoon session, N. A. Carle, from the Public Service Electric Co., Newark, N. J., chairman of the Committee on Prime Movers, will read the report of the committee, and in the second afternoon session, Thursday, May 20, the report of the Committee on Electrical Apparatus will be read by R. F. Schuchardt, chairman, Commonwealth Edison Co., Chicago.

Beauties and Power Developments of Niagara Falls

Friday, March 19, was ladies' night for the Chicago Section of the American Society of Mechanical Engineers. One of the meetings during the season is always reserved for this distinction, and in the present instance it was a joint meeting and dinner with the Western Society of Engineers. The attendance was good and the treatment of the topic of the evening, "The Development of Niagara Falls Water Power," was a revelation to those present.

William M. White, manager of the hydraulic department of the Allis-Chalmers Manufacturing Co., had a wonderful collection of motion and stationary pictures bringing out the beauties of the world's greatest scenic attraction, the rapids above the Falls, the Gorge, the Whirlpool and the river as it broadens out into Lake Ontario. In a brief introduction giving the physical data relating to the Falls, Mr. White gave as the amount of water passing over both falls as 220,000 cu.ft. per sec., the difference in level between Lake Erie and Lake Ontario, or the total head available, as 327 ft., and the power it was possible to develop, 7,000,000 hp. The amount of water to be diverted by each country was 36,000 cu.ft. per sec. For the United States 16,000 cu.ft. per sec. was allowed to the Drainage Canal and the balance to power development. In the numerous plants on the American side 350,000 hp. had been developed and 450,000 hp. on the Canadian side. Views were presented giving an idea of the various plants on both sides of the river and their relative location to one another and the Falls. On the Canadian side particular attention was given to the recent development by the Hydro-Electric Power Commission of Ontario at Queenstown Heights, and among the American plants station No. 3 of the Niagara Falls Power Co. was the chief attraction.

Beginning with the intake from the waters above the upper rapids, motion pictures showed the precautions taken to guard against ice, followed the channel to the plant, showed the thirteen older units rated at 10,000 hp. each, and then particular attention was given to the three new vertical units, each of 37,500 hp. capacity and the largest hydraulic prime-movers in the world. At normal load each turbine will use 1,700 cu.ft. of water per second. The runner weighs 40,000 lb. and the entire rotor 265,000 lb. Pictures showing the foundations for these enormous machines, their erection and the placing into service of the first unit were of exceptional interest.

It was estimated that the installation of this one unit would eliminate the services of 819 men in mining, cleaning and transporting coal and placing an equivalent amount of energy on the switchboard in a steam plant. Going a little farther, if all of Niagara's power should be developed, the coal conserved annually could be made up into a train that would extend around the world. In addition thousands of men would be released for other industries where they are badly needed. These two factors were made the basis of a strong plea for the more comprehensive development of our water power.

As an interesting conclusion Mr. White had pictures showing the war developments at Niagara, the great chemical plants, the making of carborundum and alundum and other uses of Niagara power.

Preliminary to this most interesting presentation a nominating committee was appointed, consisting of P. M. Chamberlain, H. E. Troutman, J. L. Hecht, John Wintercorn and Harry Mimelblau. The committee is to present a ballot at the April meeting, so that the officers of the section for the ensuing year may be elected in accordance with the by-laws at the last meeting of the season, which will be held in May.

It is conservatively estimated that the December storm of last year cost the Pacific Power and Light Co. between $30,000 and $35,000 in increased operating expense due to purchased power, coal, and inability to deliver service. There was also trouble in January, caused by snow and frost adhering to the Yakima Valley lines, and the aluminum conductors broke in many places. This caused interruptions to service and made it necessary to pull very heavily on the Washington Water Power Co.

New Publications

McGRAW CENTRAL STATION DIRECTORY AND DATA BOOK. Published by McGraw-Hill Co., Inc., New York City, 1919. Flexible Binding; 4 x 8 in.; 835 pages. Price, $15.

This new edition contains completely revised data on 6,106 operating companies' power systems and their 1,700 additional generating plants and substations, in the United States, Canada, West Indies and Mexico. There are 416 new companies included in this edition, and 3,388 companies selling electrical appliances and 1,666 companies doing wiring on other electrical contracting work are definitely indicated. Five thousand towns with a population under 1,000 are tabulated, with the name of the town from which they are being served with power. A statistical summary and a list of state public-service commissions having jurisdiction over electric utilities are also included. The data regarding the companies systems cover such features as location of plant, number of generating units, total capacity, frequency, voltage, phase, direct or alternating current, length of transmission lines and voltage, capital invested, company officers, etc. This edition of the directory is more complete than any previous one and contains valuable data for all those interested in the commercial side of the electrical industry.

CONTROLLERS FOR ELECTRIC MOTORS. By Henry Duval James, B. S., M. E. Published by D. Van Nostrand Co., New York City, 1919. Cloth; 5½ x 8 in.; 350 pages; 259 illustrations. Price $3.00.

This book is a treatise on the modern industrial controller, together with typical applications to the industries, and consists of a series of articles originally published in the *Electric Journal* during 1917 and 1918, to which have been added some new text and illustrations. The author was exceptionally well qualified for the preparation of this book. Having been for a number of years the engineer in charge of the controller department for one of this country's largest electrical manufacturing companies, he has had the opportunity to get the broad viewpoint necessary for the presentation of so large and important a subject. Fortunately, he has shown a keen understanding of the requirements of the practical man and has treated his subject in a practical and easily understood way. If there is one feature in the book more conspicuous than any other, it is the almost absolute absence of mathematics. Only on three pages is the mathematical side of the subject mentioned. The work is divided into 26 chapters: Introduction; Historical; Design Details; How To Read Controller Diagrams; Methods of Acceleration; Starting Characteristics of Motors with Different Methods of Control; Methods of Speed Control and Dynamic Braking; Direct-Current Magnetic Contactor Controllers; Alternating-Current Controllers; Resistors; Protective Devices; Series-Parallel Control and the Electro-Pneumatic Contactor; Voltage Control for Direct-Current Motors Mine Hoists; Hydraulic Pumps; Machine-tool Controllers (two chapters); Control for Machinery Requiring Low Initial Speed, Such as Printing Presses and Rubber Calenders; Steel-Mill Floor Controllers for Auxiliary Drive; Cranes; Car Dumpers; Ore and Coal Bridges; Coke; Elevators; Electrical Equipment for Oil Wells; Locomotives for Mines and General Industrial Purposes.

In part of the introductory chapter the author discusses the advantages and disadvantages of the various types of controllers, which, combined with the design details treated of in Chapter III, will be of assistance to those interested in the application of controllers in forming an opinion how variations in design will affect the performance of a controller. The explanations given in Chapter IV on how to read a controller, combined with the discussion on methods of accelerating motors in Chapter V, form a groundwork for those not experienced in the art to obtain an understanding of the fundamentals of controllers that will make the following chapters on the control of both direct-current and alternating-current motors and controller applications easily understood. No attempt has been made to cover every method of control and all applications; however, those selected give a wide range of operating conditions, as indicated by the titles of the different chapters. A large number of diagrams have been given, but these have in most cases been very much simplified for the purpose of clearness.

Probably the most serious criticism that can be made of the book is that it deals with the product of only one manufacturer. However, the general principles of operation of every controller manufacturer's product are practically the same, the essential difference being in the method of application. The book contains a wealth of information for those interested in the principles and application of controllers for electric motors and should fill an important need in engineering literature.

DESIGN AND CONSTRUCTION OF HEAT ENGINES. By William E. Ninde, M. E., Associate Professor of Mechanical Engineering, Syracuse University. Published by McGraw-Hill Book Co., New York City. Cloth, 6 x 9 in., 695 pages; illustrated. Price, $6.

The author states that his object in presenting this book is to provide the material most essential to a well-equipped, independent designer of heat engines in a form most convenient for classroom and practical work. The text is divided into six parts, of which the first five are really introductory to the main division of Machine Design.

Part 1, The Heat Engine: Describes briefly the principles of operation of the three main types of prime mover, the steam engine, the steam turbine and the internal combustion and outlines the most common methods of classification of each.

Part 2, Thermodynamics: Presents the essential thermodynamic formulas on which the design of heat engines are based. The chapter on cylinder efficiency discusses the

various factors affecting the important problem of cylinder condensation in steam engines.

Part 3, Friction and Lubrication: Discusses the theory of lubrication, making special reference to the design of bearings.

Part 4, Power and Thrust: In this section the author shows the use of the indicator diagram, both actual and theoretical, in computing the power and the forces due to the steam or gas pressure. The chapter on steam turbines is an outline of the design of nozzles, guides and blades from the standpoint of the flow of steam through the machine.

Part 5, Mechanics: Treats of the various parts of the engine as mechanisms and discusses the action of the various forces due to inertia and gravity, and their combination with the forces due to the steam pressures. The theories of flywheels and of governors are presented and a considerable space is devoted to valve gears.

Part 6, Machine Design: This is, naturally, the largest division. After a general discussion of various forms of stresses and of the properties of materials the various parts of a reciprocating engine are taken up in detail. A chapter is devoted to the design of cylinders, another to pistons, a third to piston rods, and so on. Attention is also given to turbine wheels, shafts and casings.

Throughout the book an effort is made to present rational formulas and methods as far as possible and to supplement them with empirical equations and practical data from established practice. Numerous drawings of actual engine details are given to illustrate the examples. A noticeable feature is the grouping at the beginning of each chapter of the notation used in the formulas in that chapter, and in most cases the meaning of the various symbols is repeated in the text when first used. This feature goes far to facilitate the use of the book. A general knowledge of thermodynamics and of mechanics is assumed, although in some cases the author has taken considerable trouble to explain elementary details which would be familiar to one capable of understanding most of the text.

Obituary

Melvin B. Newcomb, aged 31 years, chief engineer of the rubber machinery department of The Wellman-Seaver-Morgan Co., died on Mar. 13, after a short illness at his home, Akron, Ohio. Mr. Newcomb was born in 1889 in Bridgeton, N. J. He received his mechanical engineering education at the University of Wisconsin. He has been engaged in engineering work with the I. P. Morris Co., Philadelphia, the Allis Chalmers Manufacturing Co., Milwaukee, Wis., the Wisconsin Engine Co., Corliss, Wis., and the Firestone Tire & Rubber Co., Akron. In January, 1918, he joined the hydraulic turbine engineering department of The Wellman-Seaver-Morgan Co. A few months later he was appointed chief engineer of the rubber machinery department of The Wellman-Seaver-Morgan Company.

Mr. Newcomb was a member of the American Society of Mechanical Engineers, The Cleveland Engineering Society, and the Akron Engineering Society.

He is survived by a wife and two young daughters.

Personals

John A. Stevens, power plant engineer, Lowell, Mass., has opened a branch office at 502 Frederick Building, Cleveland, Ohio.

Ralph T. Bratt and **Carl T. Petersen** have formed a partnership as consulting engineers in power plants, heating, ventilating and refrigeration at Hackensack, N. J.

Edward M. Burd and William C. Giffels have opened an engineering office in Grand Rapids, Mich. Both are University of Michigan graduates and were formerly connected with the Consumers' Power Co., in Michigan.

M. A. Buehler, formerly sales manager at the Omaha office of the Western Electric Co., has been made sales manager at the Minneapolis office. Eliot Lum, of the sales department of the Omaha house, will succeed Mr. Buehler.

W. E. Herring, well-known on the Pacific Coast as the industrial agent of the Puget Sound Traction, Light & Power Co., Seattle, Wash., has been transferred to the engineering department in the Boston office of Stone & Webster. Mr. Herring formerly was chief engineer of the United States Forestry Service.

J. C. McKenzie, who, for over a year, has been with the Performance Branch, Emergency Fleet Corporation, in charge of trial trip data, New York office, has accepted a position as marine engineer with the Power Specialty Company, New York. He will be in charge of the Service Department for Foster Marine Superheaters and Foster Marine Boilers.

Clarence Goldsmith, who has been on the enginering staff of the National Board of Fire Underwriters, 76 William Street, New York City, for the past twelve years and late a major in the Construction Division of the United States Army, has been placed in charge of the branch enginering office recently established by the National Board at 234 South La Salle Street, Chicago, Ill.

Engineering Affairs

The American Order of Steam Engineers will hold its annual convention at Baltimore, June 7 to 11, inclusive.

The Association of Iron and Steel Electrical Engineers will hold a meeting on April 17, 1920. A paper entitled, "Grounded Neutral" will be read by Robert B. Treat, Electrical Engineer, General Electric Co., Schenectady, N. Y.

Miscellaneous News

The Union Francaise d'Electricite, France, is erecting near Paris the largest power station in Europe. Sixty thousand hp. turbines will be installed and the complete capacity of the plant, when finished, will be 400,000 hp.

Erection of the Two Largest Boilers in Tennessee is under way at the city light plant at Nashville. Each boiler weighs 55 tons and the two stokers weigh 28 tons each. The cost of the boilers (not including foundation) to the city is $51,854.

The City Commission of Trenton, N. J., has decided on the installation of mechanical devices on the city pumping station along the Delaware River to overcome the smoke nuisance. A Bureau of Smoke was established to rid the city of smoke from the Trenton factories.

The American Chamber of Commerce in London reports the erection of a gigantic copper refinery, costing approximately $50,000,000, at Newton Abbott, Devonshire, England. The required electrical energy will be generated from deposits of 800,000,000 tons of lignite, a new smokeless fuel, which is located near the site of the plant.

The Trenton-Mercer County Traction Corp., Crescent Belting & Packing Co., De Laval Steam Turbine Co., and many other Trenton, N. J., plants were forced to close their boiler rooms which became flooded when the Assanpink Creek overflowed its banks. The city commission at a recent conference decided to construct a long retaining wall along the creek for the protection of the power plants.

Business Items

The Westinghouse Electric and Manufacturing Co. has awarded contracts for the construction of a new plant at South Philadelphia, Pa. The new plant will be used for the building of turbines.

The Midwest Engine Co., Indiana, recently completed a testing laboratory having facilities for testing centrifugal pumps up to 48-in. capacity. Twenty-five gallons of water per minute is the capacity of the plant.

The Black & Decker Mfg. Co., Towson Heights, Baltimore, Md., announce the establishment of a permanent office and show room at 1436 South Michigan Avenue, Chicago, Ill., this office will be in charge of R. G. Ames, whose territory has been extended to cover the entire Mid-West.

W. B. Connor, Inc., have taken on the agency of the International Engineering Works, Inc., of Framingham, Mass., for the metropolitan district and export. This company represents in addition: Dayton-Dowd Co., Quincy, Ill.; Scranton Pump Co., Scranton, Pa.; The Sims Co., Erie, Pa.; Erie Engine Works, Erie, Pa.

The George Cutter Co., of South Bend, Ind., announces the acquisition by the Westinghouse Electric and Manufacturing Co. of a financial interest in former company. The management and the commercial policies will remain unchanged, but advantage will be taken of the Westinghouse engineering and other facilities to expand the Cutter company's activities and develop its lines to enable it to more effectively serve its customers and the industry. The Westinghouse company will operate as sole distributors for the Cutter company's products.

Trade Catalogs

The Armstrong Machine Works, Michigan, has just issued a 32-page booklet describing the operation, application and construction of steam taps.

The Page Boiler Co., of Chicago, has just completed a 38-page catalog dealing with economical steam production and the building up of boiler efficiency. A copy will be sent upon request.

The Erie Pump and Equipment Co., Erie, Pa., has just issued a thirty-two page booklet describing various styles and features of their Class M Voliete Centrifugal pumps. The booklet will be sent upon request.

The De Laval Steam Turbine Co., of Trenton, N. J., has recently published an eight-page booklet describing tests made by the cities of Minneapolis and St. Paul, upon De Laval centrifugal pumps. A copy will be sent upon request.

The E. M. Dart Manufacturing Co., of Providence, R. I., has ready for distribution a new 31-page catalog. This booklet describes the couplings, unions, flanges, etc., manufactured by the E. M. Dart Co. A copy will be sent on request.

The Erie Pump and Engine Works, Inc., Medina, N. Y., has ready for distribution a seven page pamphlet describing low head centrifugal pumps and a thirty-two page booklet dealing with centrifugal dredging pumps. Copies will be sent upon request.

Dry Steam is the title of a 21-page booklet recently issued by the Tracy Engineering Co., of San Francisco, Cal. It describes various methods of overcoming the difficulties incident to wet steam. A copy of the pamphlet will be sent upon request.

The Star Brass Works, Manufacturing Engineers, Chicago, now have ready for distribution a new 24-page booklet dealing with spray cooling equipment for the cooling of water from steam and ammonia condensers. A copy of the booklet will be sent on request.

The Smooth-On Manufacturing Co., of Jersey City, N. J., has ready for distribution a new 31-page booklet entitled "Smooth-On Home Repairs." The catalog describes methods for the repair of boilers, radiators and furnaces. A copy will be sent on receipt of request.

The Green Fuel Economizer Co., Beacon, N. Y., recently issued a 44-page, illustrated bulletin, No. 152, on "Hi-Efficiency, Hi-Speed Radial Flow Fans—Forced Draft Service." The development and design, pressures and capacities developed of these fans are all fully described. Added are 12 pages of dimension sheets and 19 pages of capacity tables.

The Locomotive Superheater Co., of New York and Chicago, has completed a new 8-page booklet entitled "Superheaters for Stationary Power Plants." A clear, concise argument is given, covering the advantages of superheated steam, which should prove of value to all power plant owners and operators. These bulletins will be sent to anyone interested on request.

Sanford Riley Stoker Co., Worcester, Mass., has recently issued a 47-page second edition of its general catalog on "Riley Underfeed Stokers." This is artistically printed and illustrated on fine bristol paper and fully describes every phase of the stoker. Several pages of valuable engineering data are also contributed by the company's service department. This is for general distribution to anyone interested in boiler room equipment.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$8.20@$8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	3.60@ 3.80
Rice	2.30@ 2.50
Barley	1.25

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.85@$3.35	$3.15@$3.60
F.o.b. Philadelphia, gross tons	5.05@ 5.60	5.35@ 5.90
F.o.b. New York, gross tons	5.40@ 5.95	5.75@ 6.25
Alongside Boston (water coal), gross tons	7.00@ 7.75	7.60@ 8.00

Pocahontas and New River are practically off the market for coastwise shipment, but are quoted at $6.25@$7.00.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

Anthracite

	Company Coal
Broken	$7.80@$8.25
Egg	8.20@ 8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	5.15
Rice	4.50
Barley	4.85
Boiler	4.85

Bituminous

Government prices at mines:	Spot
South Fork (best)	$3.25@$3.50
Cambria (best)	3.00@ 3.25
Cambria (ordinary)	2.60@ 2.90
Clearfield (best)	3.00@ 3.25
Clearfield (ordinary)	2.60@ 2.90
Reynoldsville	2.85@ 2.90
Quemahoning	3.25@ 3.50
Somerset (medium)	3.00@ 3.25
Somerset (poor)	2.50@ 2.75
Western Maryland	2.50@ 2.75
Fairmont	2.25@ 2.50
Latrobe	2.60@ 2.90
Greensburg	2.75@ 3.00
Westmoreland ¾ in	3.40@ 3.50
Westmoreland run-of-mine	2.75@ 3.00

PHILADELPHIA—Bituminous coal prices vary according to district from which they are mined. For ordinary slack the price is $2.45@$2.55; lump $3.35, at the mines.

BUFFALO—

Anthracite

	On Cars, Gross Ton	At Curb, Net Ton
Grate	$8.55	$10.80
Egg	8.80	10.65
Stove	9.00	10.85
Chestnut	9.10	10.85
Pea	7.75	9.30
Buckwheat	5.70	7.75

Bituminous

Allegheny Valley	$4.80
Pittsburgh	4.65
No. 8 Lump	4.65
Mine-run	4.80
Slack	4.10
Smokeless	4.60
Pennsylvania Smithing	5.70

CLEVELAND—Prices of coal per net ton delivered in Cleveland are:

Anthracite

Egg	$12.25@$12.40
Chestnut	12.50@ 12.70
Grate	12.25@ 12.40
Stove	12.40@ 12.60

Pocahontas

Nine-run	$7.50

Domestic Bituminous

West Virginia split	$8.50
No. 8 Pittsburgh	$6.60@ 6.90
Massillon lump	8.25@ 8.50
Coshocton lump	7.15

Steam Coal

No. 6 slack	$5.25@$5.50
No. 8 slack	5.10@ 5.50
Youghiogheny slack	5.25@ 5.50
No. 8 ¾ in	5.70@ 6.60
No. 6 mine-run	5.25@ 5.50
No. 8 mine-run	5.75

Only coal available is mine-run Pocahontas.

MIDDLE WEST—Chicago quotations, f. o. b. cars at mine:

	Springfield, Carterville, Williamson, Franklin, Saline, Harrisburg	Fulton, Peoria	Grundy, La Salle, Bureau, Will
Lump	$2.55@$2.70	$2.95@$3.10	$3.25@$3.40
Washed	2.75@ 2.90		3.45@ 3.60
Mine-run	2.35@ 2.50	2.75@ 2.90	3.00@ 3.15
Screen'gs	2.05@ 2.20	2.35@ 2.50	2.75@ 2.90

New Construction

PROPOSED WORK

Mass., Northampton—George F. Newton, Archt., 6 Beacon St., Boston, will soon award the contract for the construction of a 2 story, 175 x 200 ft. hospital building, for the Lathrop Home, 236 South St. A steam heating system will be installed in same. Total estimated cost, $250,000.

Mass., Salem—The Salem Electric Lighting Co., 201 Devonshire St., is in the market for turbine and boilers.

Mass., Worcester—Cutting, Carlton & Cutting, Archts., 44 Front St., will soon receive bids for the construction of a 1 and 2 story garage and service building on Park Ave., for Henry J. Murch, 731 Main St. A steam heating system will be installed in same. Total estimated cost, $150,000.

R. I., Providence—The Narragansett Electric Lighting Co., 800 Turks Head Bldg., will soon award the contract for the construction of a 75 x 95 ft. power house addition on South St. Estimated cost, $700,000.

Conn., Norwich—H. S. Goldfaden, 388 West Main St., will soon award the contract for the constructoin of a 3 story theatre on B'way. A steam heating system will be installed in same. Total estimated cost, $150,000. George E. Pitcher, 65 B'way, Engr.

N. Y., Alden—The Supervisors of the Co. Home and Hospital will soon receive bids for the construction of 12 separate buildings, including a separate building for power and heating plant. Total estimated cost, $1,700,000. G. C. Diehl, Ellicott Sq., Buffalo, Engr.

N. Y., Brooklyn—Abraham & Strauss, 422 Fulton St., are having plans prepared for altering the 5 story department store building at 422 Fulton St. A steam heating system will be installed in same. Total estimated cost, $130,000. Starrett & Van Vleck, 8 West 40th St., New York City, Archts. and Engrs.

N. Y., Brooklyn—The Brooklyn Retail Butchers' Corp., 3285 Fulton St., is having plans prepared for the construction of a 3 story, 130 x 135 ft. ice plant and storage house on Atlantic Ave. and Fort Greene Pl. Total estimated cost, $400,000. J. H. H. Voss, 154 Nassau St., New York City, Archt. and Engr.

N. Y., Brooklyn—R. Sanders, 188 Prospect Park West, is in the market for complete saw-mill equipment, including steam engine and boiler.

N. Y., Brooklyn—The School of Our Lady of Lourdes, Rev. J. McMahon, Pastor, will soon award the contract for the construction of a 4 story school addition on Aberdeen St. A steam heating system will be installed in same. Total estimated cost, $300,000. Helmle & Corbett, 189 Montague St., Archts. and Engrs.

N. Y., Lackawanna—St. Patrick's Parish, Father Baker, Pastor, plans to construct 2 buildings including church and school. A steam heating and ventilating system will be installed in same. Total estimated cost, $100,000 to $130,000.

N. Y., Long Island City—W. Higginson, Archt. and Engr., 18 East 41st St., New York City, will soon award the contract for the construction of an 8 story, 85 x 345 ft. factory on Mount St., for H. Lockhart Jr., 501 5th Ave., New York City. A steam heating system will be installed in same.

N. Y., Marcy—The State Hospital Comm., Capitol, Albany, received bids for installing a steam heating system in the mortuary, laboratory and tuberculosis hospital at the Utica State Hospital, here, from Thomas Breen Co., 414 Lafayette St., $17,413; H. J. Brandeles, 433 Lafayette St., $18,245; Mohawk Valley Heating Co., 302 Broad St., $20,745; all of Utica. Noted March 3.

N. Y., Massena—The Massena Farmers Co-operative Corp. is in the market for a refrigeration system, steam boiler equipment and transmission and complete creamery machinery. Address James Phillips.

N. Y., New York—The Bd. Educ., 500 Park Ave., is having plans prepared for the construction of a 4 story school building on 176th St. and Audubon Ave. A steam heating system will be installed in same. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., Archt. and Engr.

N. Y., New York—E. Dwight, 56 Maiden Lane, is having plans prepared for altering the 8 story loft building and warehouse on William and John Sts. A steam heating system will be installed in same. Total estimated cost, $150,000. Butler & Rodman, 56 West 45th St., Archts. and Engrs.

N. Y., New York—M. R. Huntington, 10 East 58th St., is having plans prepared for the construction of a 2 story, 85 x 100 ft. theatre on Washington Pl. A steam heating system will be installed in same. Total estimated cost, $250,000. William J. Cherry, Grand Central Station, Archt. and Engr.

N. Y., New York—The New York Telephone Co., 15 Dey St., is having plans prepared for the construction of an 80 x 192 ft. automatic telephone exch. building on 73rd St. between Columbus and Amsterdam Ave. A steam heating system will be installed in same. Total estimated cost, $1,540,000. McKenzie, Voorhies & Gmelin, 1123 B'way, Archts. and Engrs.

N. Y., New York—Thompson & Binger, Archts. and Engrs., 280 Madison Ave., is having plans prepared for the construction of an 18 story, 75 x 80 ft. office building on Franklin and Gold Sts. A steam heating system will be installed in same. Total estimated cost, $400,000. Owner's name withheld.

N. Y., Ossining—The Bd. Educ. will receive bids about April 10 for the construction of a 2 story school building. A steam heating system will be installed in same. Total estimated cost, $60,000. Wilson Potter, 22 East 17th St., New York City, Archt. and Engr.

N. Y., Ripley—The Telling-Belle Vernon Co. plans to take over the plant of the Ripley Milk Products Co. and is in the market for a 150 hp. boiler.

N. Y., Seneca Falls—Harry Nothnagle is in the market for cold storage equipment.

N. Y., Watertown—The Beebes Island Corp. is having plans prepared by J. G. White Co., 215 Thompson St., New York City, for the construction of a power house on Beebes Island. Estimated cost, $500,000. C. H. Starbuck, New York Air Brake Co., 165 B'way, New York City, Pres.

N. J., Lakehurst—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., is having plans prepared for the construction of a 36 x 73 ft. power house with a three 300 kw. generating capacity and the installation of a 50 x 111 ft., 3,000 hp. boiler. Total estimated cost, $500,000. Noted Feb. 3.

N. J., Newark—The Wright Aeronautical Corp. of America, 40 Wall St., New York City, will soon award the contract for the construction of a 2 story, 45 x 200 ft. factory on Meiker Ave. A steam heating system will be installed in same. Total estimated cost, $350,000. J. W. Ingle, 527 5th Ave., New York City, Archt. and Engr

N. J., Westfield—E. Lynch, Archt. and Engr., 341 5th Ave., New York City, will soon award the contract for the construction of a 1 story, 65 x 115 ft. church for the Holy Trinity Church. A steam heating system will be installed in same. Total estimated cost, $100,000.

Pa., Connellsville—The Paragon Motor Co., 404 Century Bldg., Cleveland, O., is having plans prepared for the construction of a 1 story, 60 x 400 ft. and a 1 story, 40 x 540 ft. factory building. Plans include the construction of a steam power plant. Total estimated cost, $500,000. F. F. Hockenthal, 404 Century Bldg., Cleveland, O., Engr.

Pa., Easton—The Y. M. C. A., 347 Madison Ave., New York City, is having plans prepared for the construction of a 4 story Y. M. C. A. building. A steam heating system will be installed in same. Total estimated cost about $250,000. Martin & Kirkpatrick, 130 South 15th St., Philadelphia, Archts. and Engrs.

Pa., Philadelphia—The Queens Brooks Co., American and Diamond Sts., is having plans prepared for the construction of a 5 story, 50 x 200 ft. factory on 5th St. and Hunting Park. A steam heating system will be installed in same. Total estimated cost, $100,000. W. E. S. Dyer, Land Title Bldg., Archt. and Engr.

Pa., Pittston—The Pennsylvania Coal Co. plans to build a 50 x 90 x 200 ft. coal breaker, cost, $750,000 and a 30 x 40 x 40 ft. electric power plant, cost, $200,000.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., is having plans prepared for the construction of an underground steam heating system at the Naval Operating Base, here.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., is having plans prepared for the construction of an underground electric distributing system at the Naval Operating Base, here.

Va., Richmond—The Westmorehead Club Grace St., is having plans prepared for the construction of a 3 story, 80 x 140 ft. club house. A steam heating system will be installed in same. Total estimated cost, $350,000. G. Bryan, Pres. Alfred C. Bossom, 680 5th Ave., New York City, Archt. and Engr.

W. Va., Charleston—Lockwood Greene & Co., Archts. and Engrs., 101 Park Ave., New York City, will receive bids until April 5 for the construction of a 3 story, 52 x 200 ft. silk throwing mill for the Sauquoit Silk Mfg. Co. A steam heating system will be installed in same.

N. C., Graham—The city plans to construct a sewer, install 2 pumping stations and is in the market for 2 motor driven, centrifugal pumps. Total estimated cost, $100,000. Norcross & Keis, Atlanta, Ga., Engrs.

S. C., Charleston—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until April 15 for the installation of a lighting plant and water supply system at the U. S. Quarantine Station, here.

S. C., Gaffney—The Musgrove Mills plans to build a 3 story, 107 x 290 ft. cotton cloth mill equipped with individual electric drive, complete fire protective apparatus, etc. J. E. Sirrine, Engr.

S. C., Greenville—Furman University plans to build a 40 x 60 ft. central heating plant to supply all their buildings. Two 100 hp. boilers, ultimate capacity 500 hp will be installed in same. J. E. Sirrine, Engr.

O., Cleveland—The Beckman Co., 3167 Fulton Rd., plans to build a 2 story, 200 x 200 ft. weaving factory on Fulton Rd. and West 33rd St. A steam heating system will be installed in same. Total estimated cost, $400,000. Lockwood Greene & Co., Bangor Bldg., Archts. and Engrs.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., is having plans prepared for the construction of a 3 story, junior high school on Hopkins Ave. near East 123rd St. Two boilers will be installed in same. Total estimated cost, $1,250,000. W. R. McCormack, Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., is having plans prepared for the construction of a 3 story, 200 x 400 ft. junior high school on East 117th St. and The Speedway. A steam heating system will be installed in same. Total estimated cost, $600,000. F. G. Hogan, Dir. W. R. McCormack, Archt.

O., Cleveland—The city received bids for installing two 125 hp. boilers and stokers, from the Wickes Boiler Co., Saginaw, Mich., $12,157; Union Iron Wks., Rockfir Bldg., Cleveland, $13,120. Noted March 16.

O., Cleveland—The city plans to build a 2 story police station on East 37th and Woodland Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. A. B. Sprosty, City Hall, Dir. of Pub. Safety. F. H. Betz, 604 City Hall, Archt.

O., Cleveland—The city plans to construct a waterworks pumping station including tunnel and crib in the Lake Erie filter plant and pumping equipment. Total estimated cost, $10,000,000. A. V. Ruggles, City Hall, Engr.

O., Cleveland—The Cleveland Ry. Co., Leader-News Bldg., plans to construct a 1 story sub-station on East 130th St. and Woodland Ave. Estimated cost, $75,000. J. Stanley, Pres. D. W. Morrow, 4500 Euclid Ave., Archt.

O., Cleveland—Otis R. Cook, East 46th St. and Prospect Ave., will soon award the contract for the construction of a 5 story, 100 x 104 ft. commercial building. A steam heating system will be installed in same. Total estimated cost, $500,000. Lehman & Schmitt, Electric Bldg., Archts.

O., Cleveland—The Natl. Acme Co., 7500 Stanton Ave., is having plans prepared for the construction of a 1 story factory addition on East 131st St. and Coit Rd. A steam heating system will be installed in same. Total estimated cost, $500,000. A. W. Henn, Pres. G. S. Rider & Co., Century Bldg., Archt. and Engr.

O., Cleveland—W. Taylor Son & Co., 630 Euclid Ave., plans to build a 10 or 12 story, 135 x 265 ft. warehouse on East 17th St. and Superior Ave. Three boilers will be installed in same. Total estimated cost, $1,500,000. C. H. Strong, Mgr.

O., Cleveland—C. Shane, 2147 Ontario St., is having preliminary plans prepared for the construction of a 12 story store and office building on East 4th St. and Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $750,000. W. S. Longee, Marshall Bldg., Archt.

O., Jackson—The Wellston Iron Furnace Co. is in the market for a 100 hp., d.c., 250 volt motor.

O., Miamisburg—The City Water & Ligh Plant plans to purchase a new gas generator set for the electric light plant, consisting of dynamo and an artificial gas machine. Total estimated cost, $30,000. A W. Kepler, Supt.

Mich., Cheboygan—The city will soon award the contract for the construction of a 2 story, 60 x 120 ft. municipal building. A steam heating system will be installed in same. Total estimated cost, $150,000. L. E. Berry, Clk.

Mich., Detroit—The Bd. Educ., 50 B'way Ave., received bids for installing a heating, ventilating and plumbing system in the proposed 3 story, 100 x 250 ft. school on St. Antoine St. and Palmer Ave., from A. W. Schultz & Co., 380 Rohns St., $143,908; W. J. Rewoldt, 506 Owen Bldg., $154,920; James W. Partlan, 51 Park Pl. $155,000.

Mich., Detroit—The Detroit Water Bd had plans prepared for the construction of a 1 story, 57 x 221 ft. superstructure for a low lift or booster pumping station at the Waterworks Park. Electric motors for power will be installed in same. Total estimated cost, $100,000. T. A. Leisen, 232 Jefferson Ave., Engr.

Mich., Detroit—Aaron H. Gould & Son, 611 Empire Bldg., are in the market for ice making and refrigerating machinery.

Mich., Detroit—The Holy Redeemer Church, c/o Rev. Fr. Cantwell, Dix Ave., plans to build a 2 story church on Dix and Junction Aves. A steam heating system will be installed in same. Total estimated cost, $300,000.

Mich., Eaton Rapids — The Artificial Stone Co. is in the market for a pumping outfit, etc.

Mich., Flint—The Bd. Educ. is having plans revised for the construction of a 2 story, 208 x 287 ft. high school. A steam heating and forced ventilation system will be installed in same. Total estimated cost, $1,250,000. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Detroit, Archts.

Mich., Flint — Van Leyen, Schilling, Keough & Reynolds, Archts. and Engrs., Union Trust Bldg., Detroit, plans to build a 2 story, 40 x 130 ft. theatre on Detroit St. A steam heating boiler and a forced ventilation system will be installed in same. Total estimated cost, $100,000. Owner's name withheld.

Mich., Grand Rapids—The Bd. Educ. will soon award the contract for the construction of two 2 story school buildings, one on Dickinson St. and the other on Lafayette St. Steam heating equipment will be installed in same. Total estimated cost, $450,000. H. N. Morrell, Secy. H. H. Turner, 923 Michigan Trust Bldg., Archt.

Mich., Hamtramck (Detroit P. O.)—Warren W. Tyler, Secy. of the School Dist. 8, will receive bids until April 3 for the construction of a 2 story school building on Playfair and Goodson Aves. A steam heating and ventilating system will be installed in same. Total estimated cost, $100,000. G. J. Haas, 1514 Kresge Bldg., Detroit, Archt.

Mich., Ironwood—The city is having plans prepared for furnishing electrical pumping equipment, etc. Total estimated cost, $300,000. Alvord & Burdick, 8 South Dearborn St., Chicago, Engrs.

Mich., Jackson—The Michigan Light & Consumers Power Co., 226 West Main St., plans to build a 14,000 volt, 15 kw. substation and a single line steel tower transmission line from here to Battle Creek Total estimated cost, $410,000.

Mich., Monroe—The Monroe Paper Products Co., West Elm St., plans to build a 2 story factory. Steam heating equipment and electric power will be installed in same Total estimated cost, $100,000. J. Gilmore, Archt.

Mich., Saginaw—The Bd. Educ., c/o E. C. Oscar, engaged Cowles & Mutscheller, Archts., 1-10 Chase Block, to prepare plans for the construction of a 2 story junior high school. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Mich., Saginaw—The Modart Corset Co., 309 Lapeer Ave., plans to build a 4 story, 109 x 134 ft. mercantile building on Lapeer Ave. Steam heating equipment will be installed in same. Total estmiated cost, $300,000. Cooper & Beckbissinger, 114 South Jefferson Ave., Archts.

Ill., Chicago—The Jewish Day Nursery, 1441 Wickes Park Ave., is having plans prepared for the construction of a 2 story, 60 x 120 ft. children's home on California Ave. and Hirsch Blvd. A steam heating system will be installed in same. Total estimated cost, $100,000. Ludgin & Leviton, 53 West Jackson St., Archts.

Ill., Cicero—Childs & Smith, Archts., 64 East Van Buren St., will soon award the contract for the construction of a 1 story, 75 x 125 ft. bank on 22nd St. and Austin Ave., for the Kasper State Bank, 1900 Blue Island Ave., Chicago. A steam heating system will be installed in same. Total estimated cost, $175,000.

Wis., Kohler—The village plans an election to vote on $12,000 bonds to construct and equip an electric light system. Address A. Biotz, Village Pres. Jerry Donohue, North 8th St., Sheboygan, Engr.

Wis., La Crosse—J. C. Lewellyn, Archt., 38 South Dearborn St., will soon award the contract for the construction of a 3 story, 90 x 153 ft. school building, for the Bd. Educ. A steam heating system will be installed in same. Total estimated cost, $200,000.

Wis., Sheboygan—The Cigar Box Libr. & Mfg. Co., c/o J. Will, 1007 Michigan Ave., is having plans prepared for the construction of a 1 story, 75 x 120 ft. machine, saw, filing and power house on 15th St. Electric power will be installed in same. Total estimated cost, $50,000. Juul & Smith, Imig. Bldg., Archts. and Engrs.

Ia., Dana—Guy Meredith, Secy. of the School Bd., is having plans prepared for the construction of a 2 story consolidated school building. Separate bids for installing steam heating and plumbing systems will be received. Total estimated cost, $100,000. W. E. Hulse & Co., 210 Masonic Temple, Des Moines, Archt.

Ia., Guss—W. M. McCoy, Pres. of the School Bd., Rural Route, Nodaway Twp., is having plans prepared for the construction of a 2 story, 56 x 86 ft. consolidated school building. Separate bids for installing heating and plumbing systems will be received. Total estimated cost, $100,000. W. E. Hulse & Co., 210 Masonic Temple, Des Moines, Archt.

Ia., Marshalltown—The Bd. Educ. is having plans prepared for the construction of a 2 story, 34 x 148 ft. grade school building. A steam heating system will be installed in same. Total estimated cost, $100,000. C. E. Shutt, Co.-Supt. Tyrie & Chapman, 320 Auditorium Bldg., Minneapolis, Minn., Archts.

Ia., Rippey—A. E. Jensen, Secy. Bd. Educ., will receive bids until April 3 for the construction of a 2 story, 63 x 105 ft. school building. Separate bids for installing heating system will be received. Total estimated cost, $100,000. Proudfoot, Bird & Rawson, 810 Hubbell Bldg., Des Moines, Archts.

Ia., West Branch—T. A. Moore, Secy. of the Bd. Educ., is having plans prepared for the construction of a 3 story, 54 x 114 ft. school building. Separate bids for installing a steam heating and forced ventilation system will be received. Total estimated cost, $125,000. Proudfoot, Bird & Rawson, 810 Hubbell Bldg., Des Moines, Archts.

Minn., Deer River—H. E. Wolfe, Supt., will receive bids until April 15 for the construction of a 2 story, 80 x 110 ft. community school for the School Bd. A steam heating system will be installed in same. Total estimated cost, $100,000. S. F. Broomhall, Alworth Bldg., Duluth, Archt. and Engr.

Minn., Minneapolis—The Bd Educ. will soon award the contract for the construction of a 2 story, 72 x 210 ft. school building on 51st St. and 29th Ave., South. A steam heating system will be installed in same. Total estimated cost, $150,000. G. F. Womrath, Mgr. E. H. Enger, Engr.

Minn., Minneapolis—The Bd. Educ. will soon award the contract for the construction of a 2 story, 73 x 200 ft. school building on Harriot Ave. and 38th St. A steam heating system will be installed in same. Total estimated cost, $150,000. E. H. Enger, Engr.

Minn., Minneapolis—The Bd. Educ. will soon award the contract for the construction of a 2 story, 73 x 200 ft. school building on 22nd Ave. S. and East 40th St. A steam heating system will be installed in same. Total estimated cost. $250,000. E. H. Enger, Engr.

Minn., Minneapolis—Th McMichael Investment Co., 600 Plymouth Bldg., will soon award the contract for the construction of a 2 story, 50 x 157 ft. office building at 33 7th St., South. A steam heating system will be installed in same. Total estimated cost, $500,000. Kees & Coburn, 245 Plymouth Bldg., Archts.

Minn., Rapidan—The Rapidan Creamery Co., Mankato, will soon receive bids for the construction of a 2 story, 50 x 60 ft. creamery A steam heating system will be installed in same. Total estimated cost, $75,000. Carl Mohr, Secy. Albert Schipped, 809 Coughlin-Hickey Bldg., Archt.

Kan., Lawrence—The state is having plans prepared for the construction of a 1 story 76 x 118 ft. power plant and installation of equipment. One or two water tube boilers and an additional engine unit will be installed in same. Total estimated cost, $70,000. J. A. Kimball, Bd. of Administration, Bus. Mgr. Ray S. Gamble, 1415 Fillmore St., Topeka, Archt.

Kan., Ottawa—The Baptist University is having plans prepared for the construction of a 1 story, 50 x 100 ft. power and heating plant. Estimated cost, $75,000. S. E. Price, Pres. Washburn & Stoockey, Archts. and Engrs.

S. D., Groton—A. McKiver will receive bids until April 1 for the construction of a 2 story, 100 x 150 ft. junior and senior high school for the School Bd. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $200,000. E. F. Broomhall, Alworth Bldg Duluth, Minn.. Archt. and Engr.

Mont., Wolf Point—The city plans an election April 10 to vote on $50,000 bonds to construct new wells, pumping plant, a 200,000 gal. steel storage tank, etc. Samuel Dowell, Engr.

Mo., Sugar Creek—The Bd. Educ. will receive bids until April 2 for the construction of a 2 story, 63 x 86 ft. school building and a 1 story, 24 x 50 ft. boiler house. Total estimated cost, $70,000. A $40,000 bond issue was passed Feb. 7 for the project. Ashton C. Jones, Secy A. B. Anderson, 818 New York Life Bldg., Kansas City Mo., Archt.

Tex., Denison—The city plans an election April 6 to vote on $244,000 bonds to improve electric lighting systems and to purchase electrical pumping equipment for the city reservoir.

Tex., North Fort Worth—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to construct and install deep well pumps and piping at the Naval Helium Production plant, here.

N. M., Estancia—The town plans an election April 6, to vote on $50,000 bonds to install a water system, including tank, tower, pump, engine and mains. B. H. Calkins, Engr.

Wash., Olympia—The state is having plans prepared for the construction of a power house. A steam heating system will be installed in same. Total estimated cost, $100,000. Wilder & White, 50 Church St., New York City Archts and Engrs.

Wash., Seattle—F. A. Naramore, Archt., Central Bldg., will soon award the contract for the construction of a 1 story, 200 x 240 ft. school building at Highland Park, for the Seattle School Bd. A direct steam heating system with fan driven air circulation will be installed in same. Total estimated cost. $275,000.

Wash., Wenatchee—The land owners under the Okanogan Valley Irrigation Project plan to install a pumping system including one or more pumps of 25,000 gal. per min. capacity and capable of lifting water 470 ft. Total estimated cost, $10,000. D. C. Heney, Spalding Bldg., Portland, Ore., Consult. Engr

Ore., Bend—The Bend Water, Light & Power Co. plans to install an auxiliary pumping and sterilization plant including one 1,500 gal. per min. pump and construct a 30,000 gal. reservoir. Total estimated cost, $12,000.

Ore., Forest Grove—The Masonic Lodge will receive bids in April for the construction of a Masonic home including 2 units of a 3 unit administration building to be used in connection with a group of residence cottages. Plans include a separate power house. Total estimated cost, $230,000. W. C. Knighton, U. S. Natl. Bank Bldg., Portland, Archt.

Ore., Portland—C. J. Schnabel, Chamber of Commerce Bldg., filed an application with P. A. Cupper, State Engr., Salem, to take 600 second ft. of water from the Santiam River to lighten and manufacture a 6,511.3 theoretical hp. plant and construct diversion works, etc. Total estimated cost, $800,000.

Cal., Hayward—The city is having tentative plans prepared for the purchase of the Hayward Water Company's water system and improvement of same by replacing steam pumping plant with electric pumping system, etc. Total estimated cost, $100,000. M. B. Templeton, City Clk.

Cal., Inglewood—J. H. Kew, City Clk., will soon receive bids for furnishing a 400 to 1,200 gal. capacity, centrifugal, booster pump for the city. Olmsted & Gillelen, Hollingsworth Bldg., Los Angeles, Engrs.

Cal., Los Angeles—The Bd. of Pub. Serv. Comn., 645 South Olive St., will receive bids until April 6 for furnishing hydraulic equipment, electric generators, auxiliary electric equipment, etc. E. F. Scattergood, 645 South Olive St., Engr.

Cal., Mare Island—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., is having plans prepared for the installation of a 4,000 kw. turbo generator, here.

Cal., Martinez—The Alhambra Union High School rejected bids and will revise plans for the construction of a 2 story high school. A plenum heating system will be installed in same. Total estimated cost, $125,000. J. E. Rogers, Byron Brown Bldg., Clerk. A. A. Cantin, 68 Post St., San Francisco, Archt.

Cal., Monrovia—H. S. Gierlich, City Engr., is preparing plans for the construction of a 1,000,000 gal. reservoir, deep wells, pumps and mains. The city voted a $90,000 bond issue for the project.

Cal., Santa Ana—The First Natl. Bank is having plans prepared for the construction of a 6 story, 75 x 100 ft. bank and office building. A steam heating system will be installed in same. J. Parkinson, 420 Title Insurance Bldg., Los Angeles, Archt.

N. S., Halifax—K. H. Smith, Secy. of the Nova Scotia Power Comn., will receive bids until April 8 for the construction of power dams, superstructures for two generating stations, etc., and for furnishing and installing two 1,600 kva. generators, two 2,900 kva. generators, vertical type with exciters, two 1,900 hp. turbines and two 3,450 hp. turbines.

M. I., Guam—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to build a 30 x 38 ft. extension to power house at Agana and a 26 x 35 ft. extension to power house at the Naval Radio Station, a 12 x 14 ft. extension to pumphouse, 8 x 16 ft. extension to blower house and 22 x 47 ft. with an 18 x 24 ft. wing extension to quarters, including plumbing and electric lighting systems.

Ont., Chatham—The city will vote upon by-law appropriating $371,000 to construct a rapid sand gravity filtration plant, etc. Low lift, electric driven turbine pumps will be installed in same. F. P. Adams, City Hall, Engr.

Ont., Cobourg—The Hydro Electric Comn. of Ontario, University Ave., Toronto, plans to build a radial railroad from here to Campbellford. Estimated cost. $2,500,000. F. A. Gaby, Hydro Electric Power Co. Bldg., Toronto, Engr.

Ont., Islington—The town had plans prepared for the construction of a complete new waterworks system, including a water tank, electric driven centrifugal pumps, etc. Total estimated cost, $85,000. E. A. James Co., Ltd., 36 Toronto St. Toronto, Engr.

Ont., London—The Bd. Educ., City Hall, plans to build a collegiate building on Ridout St. A steam heating system will be installed in same. Total estimated cost, $215,000. L. V. Carrothers, Hydro offices, Archt.

Ont., London—The City Council is in the market for a 10 hp. electric motor to run a concrete mixer instead of the steam engine now used. H. A. Brazier, Engr.

Ont., New Toronto—The town plans an election to vote on by-law appropriating $100,000 to construct a 2 story public school. A vacuum steam heating system will be installed in same. W. H. C. Millard, Clk.

Ont., Port Dover—The city is having estimates submitted for the construction of a waterworks system including pumphouse, reservoir, centrifugal pumps, etc. Total estimated cost, $100,000. E. A. James Co., Ltd., 36 Toronto St., Toronto, Engr.

Ont., Toronto—The Canada Realty Co., Kent Bldg., is preparing plans for the construction of a 3 story, 50 x 80 ft. bakery on Claremont St. A steam heating system and a horizontal tubular boiler will be installed in same. Total estimated cost, $70,000.

CONTRACTS AWARDED

N. H., Portsmouth—The Rockingham Co. Light & Power Co., 29 Pleasant St., has awarded the contract for the construction of a 2 story, 30 x 50 ft. power plant addition, to M. Cashman, 63 Water St., Newburyport, Mass. Estimated cost, $25,000.

Mass., Lowell—The city has awarded the contract for the construction of a 3 story, 186 x 289 ft. high school, to Daniel Walker, 529 Dutton St. A steam heating system will be installed in same. Total estimated cost, $750,000.

R. I., Barrington—The Rhode Island Lace Wks. will build a 1 and 2 story industrial housing building. A hot air heating system will be installed in same. Total estimated cost, $100,000. Work will be done by day labor.

Conn., Norwalk—The Rosenwald Wimpfheimer Inc. has awarded the contract for changing the old electric light plant into a hat factory and for the construction of a 1 story boiler house addition on Wilton Ave. and Cross St., to A. R. Malkan & Co., 7 Mechanic St. Total estimated cost, $25,000.

Mass., Springfield—The Diamond Match Co., 111 B'way, New York City, has awarded the contract for the construction of 4 buildings including a 2 story, 311 x 468 ft. factory and three 2 story storehouses, to the Turner Constr. Co., 244 Madison Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

N. Y., Brooklyn—The Atlantic Pacific Co., 317 Bradford St., will build six 4 story, 50 x 100 ft. loft buildings on Pacific and Sackman Sts. A steam heating system will be installed in same. Total estimated cost, $300,000. Work will be done by day labor.

N. Y., Long Island City—The Title Guarantee & Trust Co., 176 B'way, New York City, will build an office building on Hunter Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. Work will be done by day labor.

N. Y., New York—The 58 West 40th St. Corp., c/o E. Necarsulmer, Archt. and Engr., 507 5th Ave., has awarded the contract for the construction of a 16 story, 75 x 100 ft. store and office building on 58 West 40th St., to Leddy & Moore, 105 West 40th St. A steam heating system will be installed in same. Total estimated cost, $850,000.

N. Y., New York—The New York Central R.R., Grand Central Terminal, has awarded the contract for the construction of a 13 story addition to present office building on Lexington Ave. and 42nd St., to James Stewart & Co., 30 Church St. A steam heating system will be installed in same.

N. Y., New York—The Sarco Realty Co., 214 West 141st St., will build a 100 x 100 ft. theatre on 137th St. and 7th Ave. A steam heating system will be installed in same. Total estimated cost, $125,000. Work will be done by day labor.

N. Y., Schenectady—The Citizens Trust Co., 434 State St., has awarded the contract for the construction of a bank building to John McDermott, 436 State St. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. J., Newark—Aron Levin, Stuyvesant Ave., will build a 5 story, 50 x 140 ft. hotel at 106 Clinton Ave. A steam heating system will be installed in same. Total estimated cost, $235,000. Work will be done by day labor.

Pa., Chester—Allison & Co., Law Bldg., has awarded the contract for the construction of a 1 story, 62 x 202 ft., mill building, to the Chester Contg. and Constr. Co., Otis Bldg., Philadelphia. A steam heating system will be installed in same. Total estimated cost, $100,000.

Pa., Philadelphia—The Amer. Mfg. Co., Water and Morris Sts., has awarded the contract for the construction of a 1, 2 and 3 story factory on Shunk and Front Sts., to the Turner Constr. Co., 1713 Sanson St. A steam heating system will be installed in same. Total estimated cost, $500,000.

Pa., Pittsburgh—The Pittsburgh Association for the Improvement of the Poor, c/o E. P. Mellon, Archt. and Engr., 52 Vanderbilt Ave., New York City, has awarded the contract for the construction of a 4 story, 60 x 240 ft. office building, to Mellon Stewart, Oliver Bldg. A steam heating system will be installed in same. Total estimated cost, $300,000.

Md., Orangeville (Baltimore P. O.)—The Columbia Graphophone Mfg. Corp., Woolworth Bldg., New York City, has awarded the contract for the construction of a 6 story, 260 x 380 ft. cabinet factory and an 85 x 100 ft. power house, etc., on East Preston St. and Loneys Lane, to the M. A. Long Co., 1523 Munsey Bldg., Baltimore. Total estimated cost, $2,500,000.

W. Va., Kanawha City—Libby Owens has awarded the contract for the construction of power plant addition near Charleston St., to the Howard P. Foley Co., 1413 G St., Wash., D. C. Estimated cost, $50,000.

Ga., Elberton—The First Natl. Bank of Elberton has awarded the contract for the construction of a 4 story bank and office building, to W. G. Sutherlin, Greenwood. A steam heating system will be installed in same. Total estimated cost, $125,000.

Ga., Savannah—The Diamond Watch Co., 111 B'way, New York City, has awarded the contract for the construction of a 4 story, 57 x 196 ft. factory, to the Turner Constr. Co., 244 Madison Ave., New York City. A steam heating system will be installed in same.

Tenn., Knoxville—The County Court Bldg. Committee has awarded the contract for installing heating and plumbing system in the proposed addition to the Court House, on West Main St., to F. Cantrell Co., Inc., U. T. Grounds, at $12,685.

O., Dayton—The General Motors Co., Taylor St., has awarded the contract for the construction of a 6 story, 120 x 300 ft. factory and a power plant on 1st and Foundry Sts., to Davies, Chism & Davies, 601 Chamber of Commerce Bldg., Columbus. Total estimated cost, $250,000.

Mich., Detroit—The Cadillac Motor Car Co., Woodward Ave., has awarded the contract for the construction of a 4 story, 619 x 792 ft. automobile factory on Clark and Michigan Aves., to the Dupont Engr. Co., 435 Woodward Ave. Electric power will be installed in same. Total estimated cost, $2,780,000.

Mich., Muskegon—The city has awarded the contract for furnishing a 15,000,000 gal. reciprocating pump for waterworks system, here, to The Allis Chalmers Mfg. Co., West Allis St., Milwaukee, Wis., at $64,900.

Mich., St. Clair—The Diamond Crystal Salt Co. has awarded the contract for the construction of a 2 story, 100 x 160 ft. warehouse along the waterfront, to J. O'Sullivan & Sons, Pine Grove Ave., Port Huron. Motors to operate conveyors will be installed in same. Total estimated cost, $125,000.

Ill., Chicago—The Clemetsen Co., 2607 Flournoy St., has awarded the contract for the construction of a 3 story, 100 x 300 ft. factory on Homan and Division St., to R. F. Wilson & Co., Market and Randolph Sts. A steam heating system will be installed in same. Total estimated cost, $200,000.

Ill., Chicago—Frederick T. Hoyt, 154 West Randolph St., has awarded the contract for the construction of a 200 x 400 ft. factory on 47th St. and Kedzie Ave., to W. McCumber, 140 South Dearborn St. A steam heating system will be installed in same.

Ill., Chicago—The Shotwell Mfg. Co., 1021 West Adams St., has awarded the contract for the construction of a 4 story, 100 x 200 ft. factory on Potsmer and S. Louis Sts., to R. F. Wilson & Co., Randol, and Market Sts. A steam heating system will be installed in same. Total estimated cost, $300,000.

Wis., Milwaukee—The Seaman Body Corp., 480 Virginia St., has awarded the contract for the construction of a 1 story, 50 x 90 ft. power house on Port Washington St., to Klug & Smith, Mack Block. Boilers and a steam engine will be installed in same. Total estimated cost, $50,000.

Minn., Chisholm — The Bd. Educ. has awarded the contract for installing a steam heating system in the proposed 2 story, 100 x 160 ft. grade school, to A. C. Shirmer Co., Hibbing. Total estimated cost, $275,000.

Minn., Duluth—St. Mary's Hospital Bd., 3rd St. and 5th Ave., East, has awarded the contract for the construction of a 6 story, 41 x 140 ft. hospital addition, to McLeod & Smith, Sellwood Bldg. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $200,000. Noted Feb. 3.

Okla., Newkirk—The Newkirk Ice & Creamery Co. has awarded the contract for the remodelling of their 1 story, 50 x 100 ft. ice and creamery plant at the Santa Fe tracks, to Arthur Frank, Tulsa. One 2 hp., one 3 hp., one 4 hp., one 5 hp., two 10 hp., two 15 hp., 220 volt, a.c. motors and one 75 kw. direct connected a.c. dynamo will be installed in same. Total estimated cost, $75,000.

Ore., Grants Pass—The Grants Pass Irrigation Dist. has awarded the contract for furnishing and installing 4 pumps, pipe, etc., to the Shattuck Edinger Co. Estimated cost, $50,000.

Cal., Anaheim—The Anaheim Co-operative Orange Association will build a packing house on Center St. A boiler plant will be installed in same. Work will be done by day labor.

Cal., Burlingame—The City Trustees have awarded the contract for furnishing and installing 2 pumping units, to the Simonds Machinery Co., 117 New Montgomery St., San Francisco, at $11,110. Noted March 16.

Cal., Holt—The State Record Bd., Sacramento, has awarded the contract for installing pumping plant, etc., in the Reclamation Dist. 2021 in Mildred Island Dist., San Joaquin Co., to the Olympian Dredging Co., 249 1st St., San Francisco. Total estimated cost, $300,000.

Cal., San Francisco—P. J. Gartland, 21st and Guerero St., will build a 3 story auto building at 11th and Market Sts. A steam heating system will be installed in same. Work will be done by day labor.

Cal., San Pedro—The First Natl. Bank of San Pedro has awarded the contract for the construction of a 5 story, 50 x 100 ft. bank and office building on 6th and Palos Verdes Sts., to the Foss Designing & Bldg. Co., 45 North Euclid Ave., Pasadena. A steam heating system will be installed in same. Total estimated cost, $150,000.

Que., Montreal—The Montreal Tramway Co., Tramway Bldg., has awarded the contract for the construction of a 1 story, 46 x 106 ft. power house on Cote St., to F. A. Grothe, 10 Cuthbert St. Estimated cost, $67,000.

Que., Montreal—L. Poulin Co. Ltd. has awarded the contract for the construction of a 4 story, 30 x 50 ft. cold storage building on Claude St., to L. Langevin, 228 Parc Lafontaine. Estimated cost, $22,000.

B. C., Hatzic—The Farmers' Cold Storage Association has awarded the contract for the construction of a 2 story, 60 x 150 ft. cold storage building, to B. Davidson, 1012 Broughton St., Vancouver. A 5 ton ice making plant will be installed in same. Total estimated cost, $50,000.

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